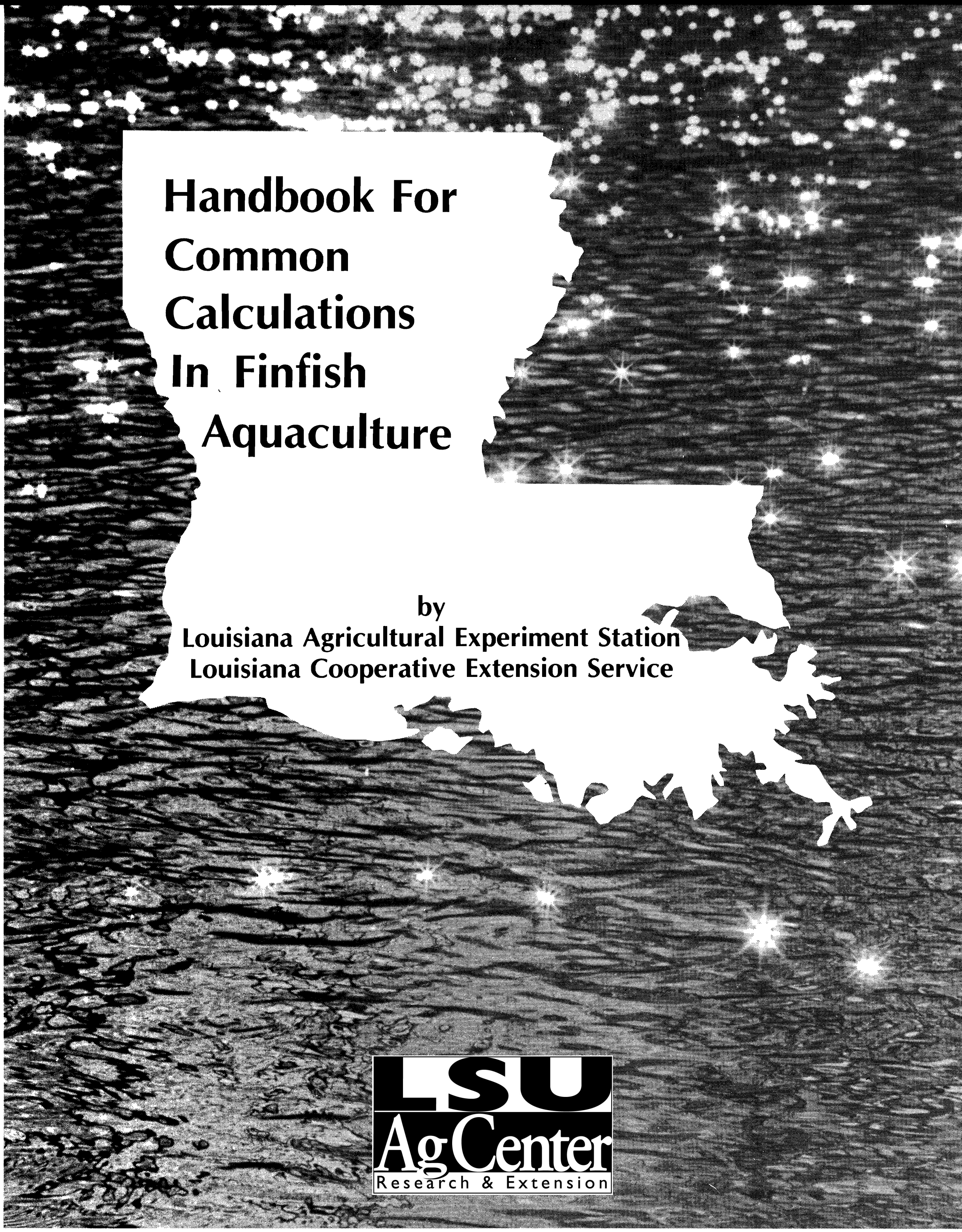
Handbook For Common Calculations In Finfish Aquaculture

by

Louisiana Agricultural Experiment Station
Louisiana Cooperative Extension Service



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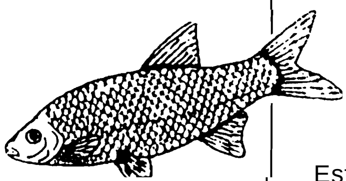

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Introduction

Aquaculture, like other agricultural practices, requires certain know-how and skills for proper management and decision-making. Aquaculture is a unique field because it crosses several disciplines including agronomy, animal science, hydrology, limnology, engineering, economics and aquaculture-the science of producing aquatic crops under managed conditions.

This handbook serves as a quick reference or guide to aid in understanding and solving problems that require calculations. Aquaculture involves problem solving and knowing how to perform various calculations correctly. This capability can translate into economic benefits and sound management decisions.

When making calculations for chemical treatments, always recheck your calculations before any treatment is applied to avoid a possible mistake that could result in under- or overtreatment rates. Also, read the product label carefully before any chemical or drug is used because it contains information on the recommended rates and uses. Any trade names or products in this publication are used for examples only and do not imply any endorsement from the Louisiana Cooperative Extension Service.

For any additional information or assistance with aquaculture-related problems, contact your local county agent of the Louisiana Cooperative Extension Service, LSU Agricultural Center.

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Determining Pond Areas

Many pond management actions are based on the surface area of water in a pond and not the volume of water. The number of fish to stock, the amount of fertilizer or lime to add, and the treatment rates of several aquatic herbicides are determined by the water area in a pond. Pond levees will wear down with time, and pond areas will change as the water level fluctuates. All ponds should have a designed water depth. This is the elevation at the top of the overflow pipe or spillway. Ponds are not one standard shape nor made with concrete walls to prevent bank erosion. The areas of all ponds on a commercial fish farm should be determined accurately and this information kept handy for reference.

The following methods and information can be used to make an accurate estimate of your pond area. Pond areas can also be determined by surveying with an engineer's transit. More error is made when assuming straight shorelines for ponds that have very irregular shorelines. Remember to determine distances from the water's edge or shoreline and not the top of the levee. Sketch a map of the pond, and record the distance of each section of the pond as it is measured.

Measuring Distances

The most accurate method of determining distances is with an engineer's transit using surveying techniques. Distances on **flat** land can be estimated well by either chaining or pacing. Chaining is more accurate than pacing.

Chaining

To determine distances by chaining, use a field tape to measure distances. The important thing to remember is to reset tape at proper location when measuring a long distance, and keep track of the number of times the tape length is repeated on a side. Mark the end of a measured tape length with a stake to locate the starting point for the next tape length.

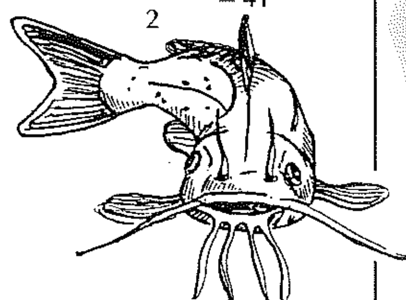
Pacing

To determine a distance by pacing, simply determine your number of strides or paces along a measured distance of 100 feet. Repeat several times using a natural walk, and take the average of your paces.

Example: Determining your pace:

First trial was 40 paces in 100 feet.
Second trial was 42 paces in 100 feet.

Average paces per 100 feet: $\frac{40 + 42}{2} = 41$



Example: Determining Distance By Pacing:

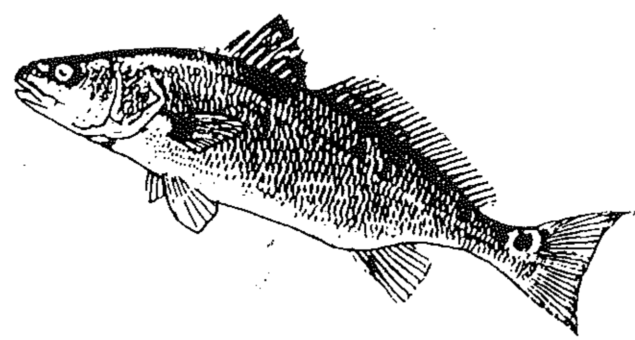
The number of paces along one bank was 387 the first trial and 395 the second trial. What is the length of the shoreline in feet?

$$\frac{387 \text{ Paces} + 395 \text{ Paces}}{2} = \frac{782 \text{ Paces}}{2} = 391 \text{ average paces}$$

$$\frac{391 \text{ Paces}}{41 \text{ Paces}} \times 100 \text{ ft.} = 9.54 \times 100 \text{ ft.} = 954 \text{ ft. length of shoreline}$$

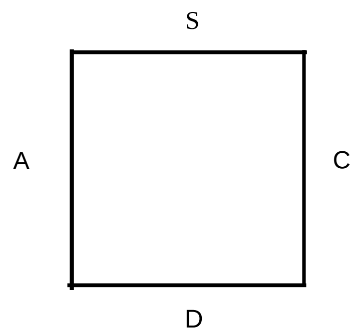
Remember, you previously determined that your pace was 41 paces or steps per 100 feet. Below is the basic formula for measuring distances by pacing.

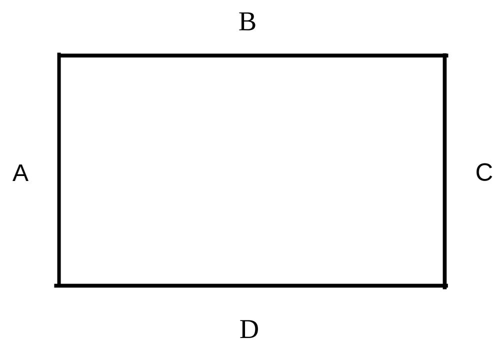
$$\frac{\text{Total Number of Paces in Unknown Distance}}{\text{Average Number of Your Paces in 100 feet}} \times 100 \text{ ft.} = \text{Distance in feet}$$



Ponds With Different Shapes

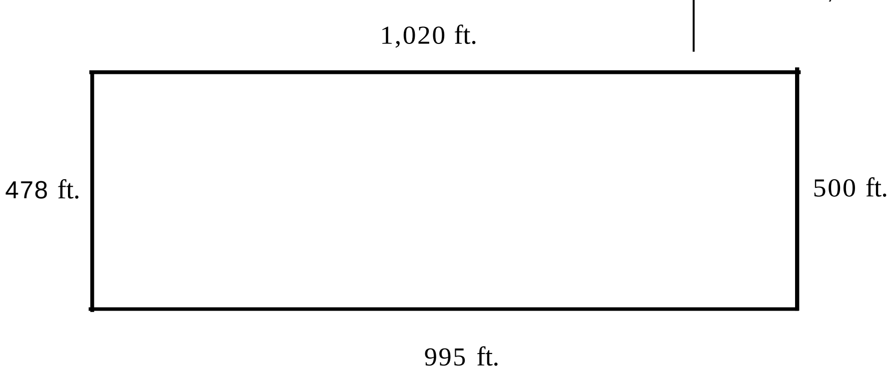
For square or rectangular ponds, use the method below. The letters on each side of the shapes represent the length of that side.





$$\frac{A+C}{2} \times \frac{B+D}{2} = \text{Area of Pond}$$

Example 1. The following lengths in feet were found for each side of the pond sketched below. What is the pond area in acres?



$$\frac{478 \text{ ft.} + 500 \text{ ft.}}{2} \times \frac{1{,}020 \text{ ft.} + 995 \text{ ft.}}{2} = \text{Area of Pond in ft.}^2$$

$$\frac{978 \text{ ft.}}{2} \times \frac{2{,}015 \text{ ft.}}{2} = 489 \text{ ft.} \times 1{,}007.5 \text{ ft.} = 492{,}667.5 \text{ ft.}^2$$

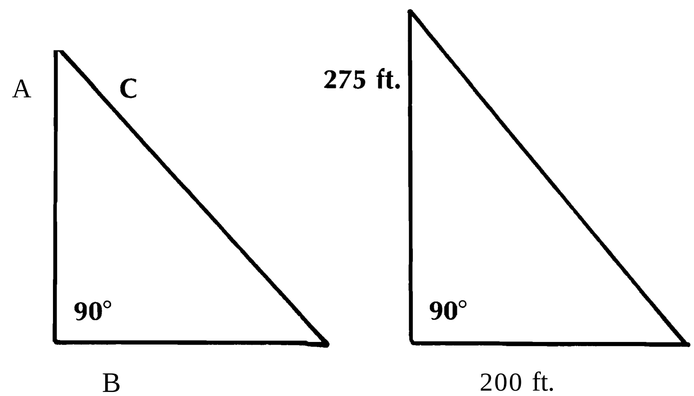
Convert ft.^{2} to acres: 1 acre = 43,560 ft.^{2}

$$\frac{492{,}667.5 \text{ ft.}^2}{43{,}560 \text{ ft.}^2/\text{acre}} = 11.31 \text{ acres}$$

For ponds with a triangular shape and 90° angle, use this method:

V2 x A x B = Area of pond

Example 2. The pond below had the following measurements.



To determine the area of Example 2:

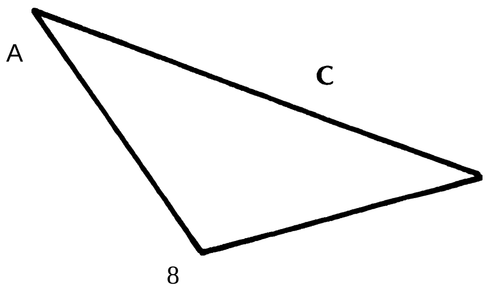
V2 x 275 ft. x 200 ft. = V2 x 55,000 ft.^{2} = 27,500 ft.^{2}

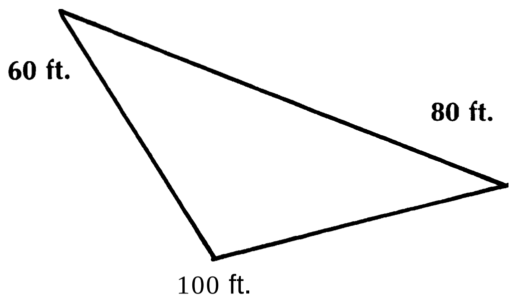
How many acres is this? Remember 43,560 ft.^{2} are in 1 acre, so:

$$\frac{27{,}500 \text{ ft.}^2}{43{,}560 \text{ ft.}^2} \times 1 \text{ acre} = 0.63 \text{ acres}$$

For ponds with a triangular shape (3 sides) and no 90° angle and unequal sides, use this method:

VS(S - A) (S - B) (S - C) = Area of Pond
Where: 5 = 1I2(A+B+C)





Example 3. Determine the area of the above pond with three unequal sides and no 90° angie.

First: 5 = 112(60 ft. + 100 ft. + 80 ft.)
S = 112(240 ft.)
S = 120 ft.

Then: Area =V1-2-0-ft-.-(-20-ft-.---6-0-ft-.-)-12-0-f-t.
-100 ft.) (120 ft. - 80 ft.)

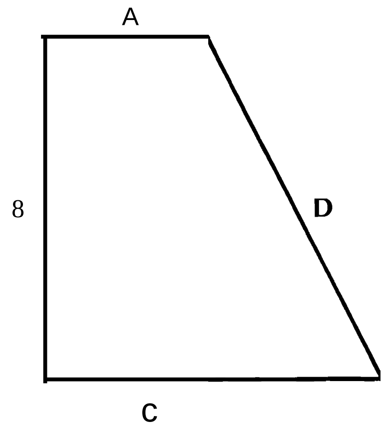
Area =V120 ft.(60 ft.)(20 ft.)(40 ft.)
Area =V5,760,000 ft.⁴

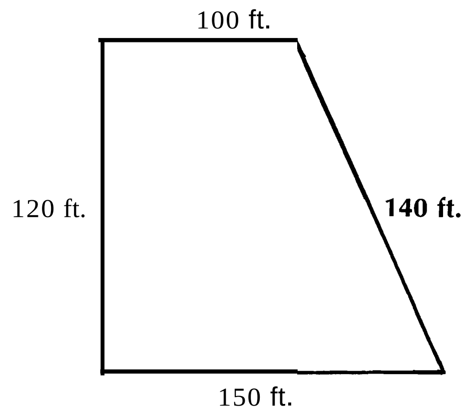
Area = 2,400 ft.² or

$$\frac{2,400 \text{ ft.}^2}{43,560 \text{ ft.}^2} \times 1 \text{ acre} = 0.055 \text{ acres}$$

For ponds with a trapezoid shape of four sides and a 90° angle, use this method:

$$\frac{A+C}{2} \times B = \text{Area of Pond}$$





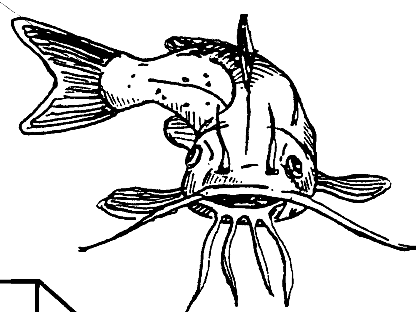
Example 4. Determine the area, in acres, of the measured pond that is shaped like a trapezoid.

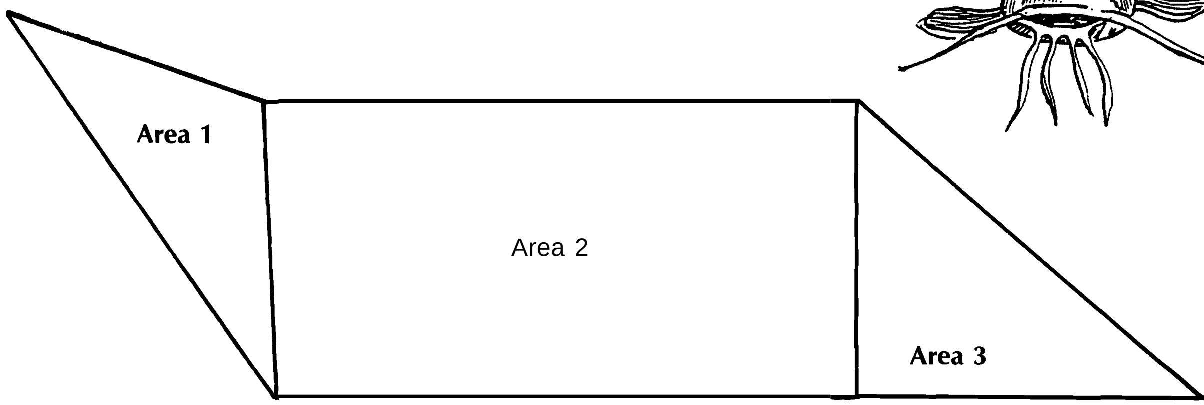
$$\frac{100 \text{ ft.} + 150 \text{ ft.}}{2} \times 120 \text{ ft.} = \text{Area of Pond}$$

$$\frac{250 \text{ ft.}}{2} \times 120 \text{ ft.} = 125 \text{ ft.} \times 120 \text{ ft.} = 15,000 \text{ ft.}^2$$

$$\text{Area in Acres: } \frac{15,000 \text{ ft.}^2}{43,560 \text{ ft.}^2} \times 1 \text{ acre} = 0.34 \text{ acres}$$

For ponds that have a mix of various shapes, divide the pond into sections that have shapes for which their areas can be determined. Then add the areas of each section to determine the area for the total pond.





Example 5. Divide the total area into sections that have shapes that can be measured for area calculations.

Area 1 is a triangle with no 90° angle and sides of unequal length. Use the method in Example 3 to determine the area of this section.

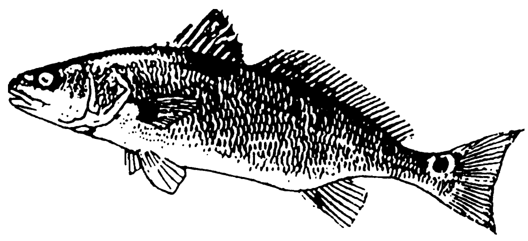
Area 2 is a rectangle. Use the method in Example 1 to determine the area of this section.

Area 3 is a triangle with a 90° angle. Use the method in Example 2 to determine the area of this section.

Total Pond Area = Area 1 + Area 2 + Area 3

Remember that not all pond shapes will fit the examples given. These methods permit a good estimate of a pond's area and should be used rather than depending on a visual estimate.

Use surveying methods to determine accurately the areas of ponds that have irregular shorelines.



Estimating Volumes of Water

In fish farming, it is necessary to know the volume of water in all fish culture facilities whether it is a vat, pond, trough or transport unit. Most chemical treatments are based on adding a recommended concentration of a chemical to the water. If the volume of water is not known or is determined incorrectly, then an overdose of the treatment can kill fish or cost more money unnecessarily. An underdose can waste money and time by not causing the desired effect.

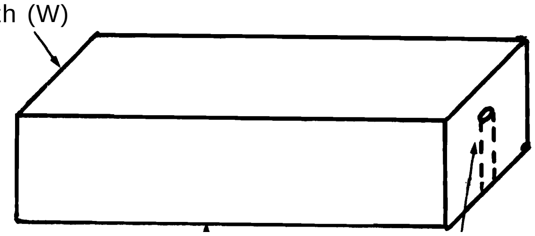
The following methods can be used to determine the volume of water in various shaped containers that are used to hold or grow fish. Very accurate determinations of water volume can be made for rigid containers or tanks. The water volume of ponds is more difficult to determine because of irregular shorelines, bank erosion, uneven bottoms and their large size.

Noncircular Tanks, Troughs, Transport Boxes

These are usually rectangular. To determine the volume, you need to know three things: 1) inside length of unit, 2) inside width of unit, and 3) average depth of water in unit.

These measurements can be made in English or metric units. In examples, we will use inches and feet.

1. Trough or Tank with Overflow Pipe and Flat Bottom use:
Water Volume = Length x Width x Water Depth



Example 1: A trough is 10 feet long and 2 feet wide with an average water depth of 10 inches. How many gallons of water are in the tank?

a. First, make sure all measurements are in the same unit. The water depth in inches should be converted to feet.

$$10 \text{ inches} = \frac{10 \text{ inches}}{12 \text{ inches}} \times 1 \text{ foot} = 0.83 \text{ feet}$$

b. Second, determine the volume of the tank in units of cubic feet (ft.^{3}):

Volume = 10 feet x 2 feet x 0.83 feet = 16.6 cubic feet

c. Finally, convert cubic feet to gallons:

16.6 cubic feet x 7.48 gallons/cubic foot = 124.17 or about 124 gallons.

2. Trough or tank with overflow pipe and sloped bottom.

Use the method in Example 1, but determine the average water depth in the tank. To determine the average water depth in a tank with a sloping bottom, measure the water depth at the shallow end, middle of the tank and deep end near overflow pipe. Determine the average depth by adding the three depth measurements and then dividing the total number by three.

Example 2. A tank is 50 feet long and 4 feet, 6 inches wide. The bottom is sloped and depth at shallow end is 3 feet, 4 inches, and depth at drain is 3 feet, 8 inches. How many gallons of water does this tank hold?

Volume = Length x Width x Average water depth

a. Determining average depth of water:

$$\text{Average water depth} = \frac{3 \text{ feet} + 3 \text{ feet and } 4 \text{ inches} + 3 \text{ feet and } 8 \text{ inches}}{3}$$

$$= \frac{9 \text{ feet and } 12 \text{ inches}}{3}$$

You cannot add unequal units like feet and inches, so convert the 12 inches to feet:

$$\frac{12 \text{ inches}}{12 \text{ inches}} \times 1 \text{ foot} = 1 \text{ foot}$$

Now substitute 1 foot for 12 inches so all the units are in feet:

$$\text{Average water depth} = \frac{9 \text{ feet} + 1 \text{ foot}}{3} = \frac{10 \text{ feet}}{3} = 3.33 \text{ feet}$$

For practical purposes, you do not have to carry out more than two numbers past the right side of the decimal. Your calculator will show 3.3333333.

b. Returning to the formula for Example 2:

Volume = 50 feet x 4 feet and 6 inches x 3.33 feet

Again, you cannot multiply numbers of different units, so you must convert 4 feet and 6 inches to feet:

$$4 \text{ feet} + \frac{6 \text{ inches}}{12 \text{ inches}} \times 1 \text{ foot} = 4 \text{ feet} + \tfrac{1}{2} \text{ foot}$$

= 4½ feet

Your calculator will not use the fraction ½, so this fraction should be converted to a decimal. This can be done easily by dividing 1 by 2 on your calculator:

½ = 1 divided by 2 = 0.5; so 4½ becomes 4.5

Now, complete the final calculation with all the units the same and no fractions in the numbers that are multiplied.

Volume = 50 feet x 4.5 feet x 3.33 feet

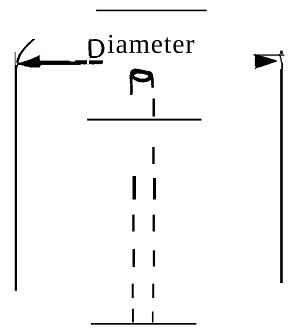
= 749.25 cubic feet ($ft.^3$)

c. Now, convert cubic feet to gallons:

749.25 cubic feet x 7.48 gallons/cubic foot

= 5,604 gallons

Circular Tank with Center Standpipe



Use the formula below to determine the volume of water:

Volume = π x r^2 x d

Where = π is a constant = 3.14

r is the radius of the tank and is equal to ½ the diameter.

d is the water depth.

r^2 means r squared or the value of r times itself (r x r).

The radius is determined by measuring the distance from the center of the standpipe to the inside edge of the tank. The diameter is determined by measuring the longest width of the tank that is the distance from two opposite sides that crosses the middle of the tank or center standpipe.

Example 3: How many gallons of water are in a circular tank that has a 3 foot high standpipe and diameter of 8 feet?

a. Volume = 3.14 x r^2 x d

r = ½ the diameter or ½ x 8 feet; ½ = 0.5
r = 0.5 x 8 feet = 4 feet

d = water depth or, in this case, the height of the standpipe
d = 3 feet

Water Volume 3.14 x (4 feet)2 x 3 feet
3.14 x 16 $ft.^2$ x 3 feet
150.7 cubic feet ($ft.^3$)

Volume in gallons = 150.7 $ft.^3$ x 7.48 gallons/$ft.^3$
= 1,127.23 gallons.

Earthen Ponds

Below is the basic formula used to estimate the volume of water in fish ponds:

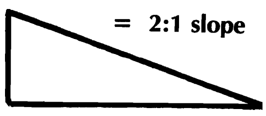
Water volume = Surface area of pond x Average water depth.

Surface area is usually expressed in acres, and water depth is in feet. The water volume of ponds is usually determined in units of acre-feet that is equal to the surface area in acres x water depth in feet.

1 acre-foot = 325,851 gallons = 43,560 $ft.^3$ = 2,718,144lbs. of water = 1 surface acre covered with 1 foot of water

Methods to determine the areas of ponds of various shapes have been presented. Now, determine the average depth of water in a pond.

The accuracy of your determination will depend on how level the pond bottom is or if it has a uniform slope. The inside slopes of levees can vary from 2:1 to 4:1. The slope affects the volume of water that can be impounded.



e

1 foot

4 feet

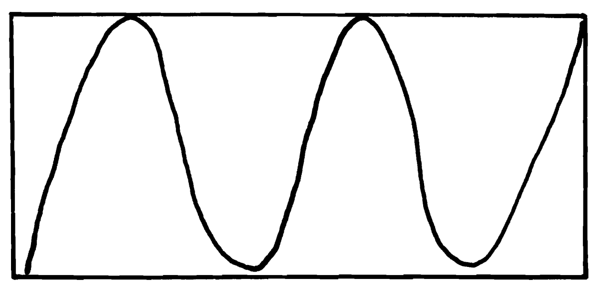
The accuracy of your estimate will also depend on the number of depth measurements that you take throughout the pond. The more measurements, the better will be the estimate.

Use the following method when the pond is empty. One easy way to determine the average depth of water is to use an engineer's transit and set it at the elevation of the designed water level or the lip of the overflow pipe. Move the Philadelphia level rod to different locations throughout the pond. Add all the height measurements, and divide by the total nurnber of stations to determine the average depth. Remember to make readings near the shoreline also.

When ponds contain water, it is necessary to wade in the pond or use a boat to take depth readings throughout the entire pond area. Again the more readings, the better the estimate.

A long pole with yardsticks attached end to end makes a good depth sounding pole. Also, it is easier when one person takes the depth and another person records the individual measurements. Take depth readings at regular intervals in a criss-cross fashion, making sure to measure both deep areas and shallow water along the bank.

Diagram showing criss-cross pattern of depth readings



To determine the average depth of water, add all of the depths measured. Then divide the total of all depths by the number of individual measurements taken. More depth measurements improve accuracy.

Example 4. What is the volume of water in a pond that has a surface area of 15.5 acres and an average water depth of 4.4 feet?

Acre-feet of water =

$$\frac{\text{Surface Area (length x width in feet)}}{43{,}560} \times \text{Average water depth in feet}$$

Acre-feet of water = Surface area in acres x Average water depth in feet = 15.5 acres x 4.4 feet = 68.2 acre-feet

How many gallons are there in 68.2 acre-feet?

68.2 acre-feet x 325,851 gallons/acre-foot
22,223,038 gallons

$$\frac{22{,}223{,}038 \text{ gallons}}{1{,}000{,}000 \text{ (1 million)}} = 22.2 \text{ million gaUons}$$

The water volume in small ponds with fill times of several days or less can also be estimated by knowing the water discharge rate of the supply pipe and the time required to fill the pond. If the soil is dry, then some water is used to moisten or saturate the soil before water is actually collected in the pond. The filling time should begin after soil is saturated and water begins to collect in the pond. For several days, evaporation is minimal. There should be no rainfall during the filling time. A good estimate of the water flow from the supply pipe is required.

Example 5. A water supply pipe provides a continuous flow of SOD gallons per minute (gpm). This pipe fills a pond in 56 hours. How many acre-feet of water does the pond contain?

$$\text{SOD gallons/minute} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = 30{,}000 \text{ gallons/hour}$$

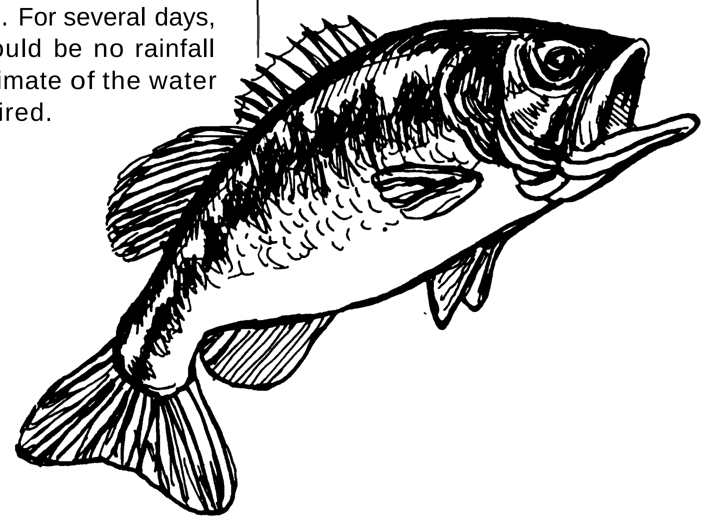
30,000 gallons/hour x 56 hours = 1,680,000 gallons in pond

$$\frac{1{,}680{,}000 \text{ gallons}}{325{,}851 \text{ gallons}} \times 1 \text{ acre-foot} = 5.15 \text{ acre-feet}$$

Another -method to estimate the volume of water in a pond is to use the formula below. This is a simple method but less accurate than the other methods.

V = A x 0.40 x D

Where: V = Volume of water in acre-feet
A = Surface area of pond in acres
D = Maximum depth of water in pond in feet
0.40 = Correction factor



Water Requirements

When planning to develop an aquaculture production facility, whether a hatchery or earthern ponds, there is a need to estimate the water required. If the water needs are not carefully evaluated, then a facility may not meet its production goal if the water supply is inadequate. A suitable water supply in both volume and quality is essential for the intensive, commercial production of fish. The following examples will illustrate the steps and calculations required to estimate the water requirements for various production units.

Example 1. A producer wants to construct four ponds in the same area and service all with one water well. The ponds vary in size and the owner wants to be able to fill any pond within 7 days. The sizes of the ponds are 6 acres, 4 acres, 5V2 acres and 3V2 acres. The average water depth in each pond is 5 feet. What flow rate in gpm is required from the service well to fill any pond in at least 7 days?

a. First determine the volume of water in the largest pond. If the largest pond can be filled in 7 days, then any smaller ponds will fill in 7 days or less.

Volume in acre-feet

6 acres x 5 feet average depth = 30 acre-feet

b. Convert 30 acre-feet to gallons:

30 acre-feet x 325,850 gallons/acre-foot = -9,775,500 gallons

c. Determine the minimum flow rate needed to fill the pond in 7 days. In this case, we are not including any adjustment for possible seepage, evaporation or rainfall.

$$\frac{9{,}775{,}500 \text{ gallons}}{7 \text{ days} \times 24 \text{ hours/day} \times 60 \text{ minutes/hour}} = 970 \text{ gpm}$$

To be on the conservative side, a 1,000 gpm well should be adequate.

Example 2: With the 1,000 gpm well from Example 1, what would be the filling time in days for the smallest pond of 3V2 acres and 5 feet average water depth?

a. First, determine the volume of water in the pond:

Volume in acre-feet =

3.5 acres x 5 feet average depth = 17.5 acre-feet

b. Convert 17.5 acre-feet to gallons:

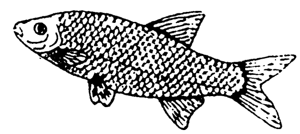
17.5 acre-feet x 325,850 gallons/acre-foot
5,702,375 gallons

c. With a flow rate of 1,000 gpm, the filling time in minutes is:

$$\frac{5{,}702{,}375 \text{ gallons}}{1{,}000 \text{ gallons/min}} = 5{,}702 \text{ minutes}$$

d. Convert 5,702 minutes to days:

5,702 minutes x 1 hr/60 minutes = 95 hours
95 hours x 1 day/24 hours = 3.96 or 4 days to fill pond



Example 3. A fish hatchery facility is being planned that will include six fish holding tanks each 4 feet wide and 30 feet long. The average water depth in each is 3 feet. The water supply for these tanks has to provide at least two complete water exchanges per hour in all tanks at the same time. The facility will also have 20 troughs each 2 feet wide and 10 feet long with an average depth of 1 foot. A water supply of 5 gpm is required for each trough and all may need water at the same time. What is the minimum water requirement in gallons per minute (gpm) for this facility?

1. First, determine the water requirement for the six holding tanks.

a. Determine the volume of water that the six holding tanks will contain.

Volume per tank =
4 feet (width) x 30 feet (length) x 3 feet (depth) = 360 cubic feet/tank

Convert 360 cubic feet to gallons:
360 cubic feet x 7.48 gallons/cubic-foot = 2,693 gallons/tank

2,693 gal./tank x 6 tanks = 16,158 gal. capacity for tanks

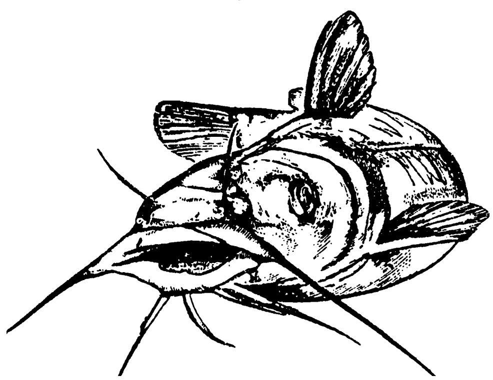
b. The desired filling time for all tanks is 1 hour or 60 minutes. The gpm required to fill tanks is calculated as follows:

$$\frac{\text{16,158 gallons capacity of all tanks}}{\text{60 minutes}} = \text{270 gpm required to fill all tanks in 60 minutes}$$

c. Determine how much water is required to supply two complete water exchanges per hour to all tanks. Two exchanges per hour means that the total volume of water in all tanks needs to be completely replaced every 30 minutes.

$$\frac{\text{16,158 gallons in tanks}}{\text{30 minutes}} = \text{540 gpm for two water exchanges per hour in all tanks}$$

The water requirement for the six holding tanks is 540 gpm. It is not 540 gpm plus 270 gpm because the maximum requirement of 540 gpm for continuous flow use can be reduced to 270 gpm to fill all tanks within 60 minutes. If fewer tanks are filled at one time or the flow rate is increased, then the filling time will decrease.



2. Now, determine the water requirements for the 20 troughs. The water requirement for these troughs needs to be added to the water requirement for the holding tanks because all facilities may be in use at the same time. First, determine the total volume of water in the troughs:

a. Volume per trough = 2 feet (width) x 10 feet (length) x 1 foot (depth) = 20 cubic feet/trough

Convert 20 cubic feet to gallons:
20 cubic feet x 7.48 gal/cubic foot = 150 gallons/trough

Total water volume in troughs:
150 gallons/trough x 20 troughs = 3,000 gallons

b. The desired filling time for all troughs is a maximum of 60 minutes. To determine the water requirement, do the following calculations:

$$\frac{\text{3,000 gallons capacity all troughs}}{\text{60 n,inutes}} = \text{50 gpm required to fill all troughs in 1 hour}$$

c. Determine the flow rate required for all troughs once they are full of water. The required continuous flow rate for each tank is 5 gpm.

5 gpm/trough x 20 troughs = 100 gpm

d. For the troughs, the water requirement is 100 gpm because only 50 gpm is needed to fill the tanks within the desired time of 1 hour.

3. To determine the total water requirement for the facility, the water requirements for each component of tanks or troughs are added. If more water is needed for other purposes that would occur when all other facilities are operating, then these water requirements are also calculated and added to the total requirement.

Total water requirement,in gpm for facility = 540 gpm for six holding tanks + 100 gpm for 20 troughs = 640 gpm

Water Filling Times

To plan times and events for fish stocking or various pond treatments, it is helpful to estimate the filling times of ponds or tanks.

To determine the filling time, we must know the volume of water that a pond or tank can hold and the flow rate of the water. The water should flow at a uniform rate continuously from start to finish. Refer to Table 1 in Appendix for pond filling times at different pumping rates.

Example 1: A pipe supplies a pond with a steady flow of 1,200 gpm. The pond can hold 65 acre-feet of water. How long will it take this pond to fill? Assume that the soil is already moist.

a. 65 acre-feet x 325,851 gallons/acre-foot = 21,180,315 gallons

$$\frac{21{,}180{,}215 \text{ gallons}}{1{,}200 \text{ gallons per minute}} \quad 17{,}650 \text{ minutes}$$

$$\frac{17{,}650 \text{ minutes}}{60 \text{ minutes/hour}} = 294 \text{ hours}$$

$$\frac{294 \text{ hours}}{24 \text{ hours/day}} = 12.25 \text{ days}$$

b. The short-cut method is:

$$\frac{21{,}180{,}215 \text{ gallons}}{1{,}200 \text{ gal/min.} \times 60 \text{ min/hr.} \times 24 \text{ hr/day}}$$

$$= 12.25 \text{ days}$$

Example 2: A trough contains 200 gallons of water. A discharge of 5 gallons per minute flows through the supply pipe. How long will it take for the tank to fill?

$$\frac{200 \text{ gallons}}{5 \text{ gallons/minutes}} = 40 \text{ minutes}$$

How many water exchanges per hour would occur if the flow rate was increased to 8 gallons per minute?

$$\frac{200 \text{ gallons}}{8 \text{ gallons/minute}} = 25 \text{ minutes to fill trough}$$

$$\frac{60 \text{ minutes (1 hour)}}{25 \text{ minutes/fill}} = 2.4 \text{ complete fills in 1 hour}$$

Flow Rates in Small Pipes

Fish culturists often need to adjust the supply of water in a pipe to obtain a desired water exchange or flow rate. Water discharge from small pipes in hatcheries or to vats can be determined easily using the following methods. Table 2 in Appendix summarizes water discharge for short drain pipes.

The flow rate is easiest to determine by using a container of a known volume. A 1-gallon container can be used or a larger container of known volume. Also needed is a stop watch or watch with a second hand. Turn on the water, then place container under pipe to collect water. With your watch, determine the time that it takes for the container to fill completely. Then make the following calculation.

$$\frac{\text{Volume of container in gallons}}{\text{Total seconds to fill container}} \times 60 \text{ seconds/minute}$$

$$= \text{flow rate in (gpm)}$$

Example 1: A 5-gallon container is filled in 45 seconds. What is the water flow rate of the supply pipe?

$$\frac{5 \text{ gallons}}{45 \text{ seconds}} \times 60 \text{ seconds/minute} = 6.67 \text{ gpm}$$

Example 2: A 3-gallon container filled up in 1 minute and 20 seconds. What is the flow rate of the supply pipe?

a. First, convert 1 minute to seconds.
1 minute x 60 seconds/minute = 60 seconds

b. Then change 1 minute and 20 seconds to total seconds.
60 seconds + 20 seconds = 80 seconds.

$$\frac{3 \text{ gallons}}{80 \text{ seconds}} \times 60 \text{ seconds/minute} = 2.25 \text{ gpm}$$

Flow rates of larger pipes can also be determined with this method. However, larger containers are required, and fill times may be only 10 to 15 seconds or less. This procedure should be repeated several times to confirm consistent results and determine an average value. For large pipes with high volume flow rates, other methods should be used to estimate discharge rates.

Feed Conversion Ratio

Feed conversion ratios are calculated to determine the cost and efficiency of feeding your fish. It is affected by the quality of feed, size and condition of fish, number of good feeding days related to temperature and water quality, and your feeding practices. Feed conversion ratios for catfish can vary -from less than 1.5 to as high as 4 or more. If your feed conversion ratio is much higher than 2, try to reduce it. It is a ratio of the pounds of weight gained by fish after consuming a known amount of feed. In commercial fish ponds, the fish get little nutrition from natural food organisms, although this is not the case for fry or a low standing crop of fish. In ponds, the feed conversion ratio represents the weight gain from any type of food the fish consumes whether it is natural or formulated.

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed Given Fish (lbs.)}}{\text{Weight Gain of Fish (lbs.)}}$$

To determine the feed conversion ratio, you must keep records of the amount of feed fed to fish in each pond and record fish losses and pounds of fish harvested. The feed conversion ratio can be calculated monthly when fish are sampled and when fish are harvested.

Feed conversion ratios are more difficult to determine when fish are topped frequently and mixed sizes of fish exist when fingerlings are stocked with much larger fish. Feed conversion ratios are easier to calculate when fish are produced in batches or single annual crops.

Use the following procedure to determine the feed conversion ratio for your fish. First, keep records for each pond of:

1. Amount of feed fed daily.
2. Initial weight and number of fish stocked.
3. Pounds of fish harvested or lost
4. Estimated standing crop of fish from pond sampling.

Your feed conversion ratio for any period

$$\frac{\text{Total Pounds Feed Fed}}{\text{Final Fish Weight-Initial Fish Weight or weight gain between sampling periods}}$$

Example 1. 67,500 fingerlings weighing 50 lbs. per 1,000 fish were stocked in a pond. Later, the fish were sampled and the average weight of fish was ¼ or 0.25 lbs., or 250 lbs. per 1,000 fish. During this time 10 tons plus 1,600 lbs. of feed were fed. No fish losses were observed. What is the feed conversion ratio?

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Amount feed fed}}{\text{Weight gain of fish}}$$

a. Convert all feed weight to one unit (pounds) instead of having two units (tons and pounds).
One ton = 2,000 lbs.
10 tons x 2,000 lbs./ton + 1,600 lbs.
= 20,000 lbs. +1,600 lbs.
= 21,600 lbs. total feed

b. Determine the weight gain of fish for this period. The final weight can be calculated using two methods:

1. Average fish weight x Number fish = Total weight

0.25 lbs./fish x 67,500 fish = 16,875 lbs.

2. $\frac{67{,}500 \text{ fish}}{1{,}000 \text{ fish}} \times 250 \text{ lbs.} = 16{,}875 \text{ lbs.}$

c. The initial weight of fish was:

$\frac{67{,}500 \text{ fish}}{1{,}000 \text{ fish}} \times 50 \text{ lbs.} = 3{,}375 \text{ lbs.}$

d. Determine the feed conversion ratio using the formula below:

$$\text{Feed Conversion Ratio} = \frac{\text{Amount feed fed}}{\text{Final weight-Initial Weight}}$$

$$\text{FCR} = \frac{21{,}600 \text{ lbs. feed}}{16{,}875 \text{ lbs.} - 3{,}375 \text{ lbs.}}$$

$$\frac{21{,}600 \text{ lbs. feed}}{13{,}500 \text{ lbs. weight gained}} = 1.6$$

The FCR means that, during the growout time, the fish consumed an average of 1.6 pounds of feed to gain 1 pound in weight.

Example 2. A pond had an estimated standing crop of 22,500 pounds of fish at the last sampling. A new sample estimated the total fish weight at 33,000 pounds. Between these two samplings, about 2,500 pounds of fish were lost. During this time, 11 tons plus 1,400 pounds of feed were fed. What is the feed conversion ratio?

a. First, convert all feed weights to the same unit of pounds.

11 tons x 2,000 lbs./tons + 1,400 lbs.
22,000 lbs. + 1,400 lbs. = 23,400 lbs. feed

b. Final weight - Last weight = Weight gain
133,000 lbs. - 22,500 lbs. = 10,500 lbs. gained

Remember, during this period 2,500 pounds of fish were lost. These fish were part of the last weight sampling when fish weighed 22,500 pounds. Also, these fish did consume feed before they were lost. From the standpoint of the feed conversion ratio, these lost fish should be included. From the standpoint of economic return, you lost both the weight gain and the feed that the fish consumed. The bottom line is how many pounds of feed did you feed your fish, and how many pounds of fish did you produce and market? Examine the feed conversion ratio from both standpoints:

1. FCR (Including lost fish)

$$\frac{\text{23,400 lbs. feed}}{\text{10,500 lbs.} + \text{2,500 lbs.}}$$

$$\text{FCR} = \frac{\text{23,400 lbs. feed}}{\text{13,000 lbs. gain}} = 1.8$$

2. Determine the feed conversion ratio that does not include the lost fish that consumed feed but which you will not market.

$$\text{FCR} = \frac{\text{23,400 lbs. feed}}{\text{10,500 lbs. (Alive)}} = 2.23$$

You can see how fish losses increase the conversion ratio. Even though fish were converting well at 1.8 pounds, the cost of production is 2.23 pounds because of the fish losses.

When fish are harvested, their weight should always be recorded and included in the total weight of fish produced to determine the feed conversion ratio. Record-keeping forms should be used to record and use the information that is needed to determine the feed conversion ratio for fish in your ponds.

Feed Requirements and Costs

The production of food fish in the U.S. involves the use of high protein feeds. A major production cost is the feed bill. The cost of feeding fish is determined by the feed conversion efficiency of fish and cost of feed. Fish farmers should know how to estimate their feed requirements over time for planning purposes and know their feed costs.

Feed Costs

Table 1 illustrates how the feed conversion ratio (FCR) and price of feed affect the cost of producing fish. With this information the per acre feed cost can be estimated.

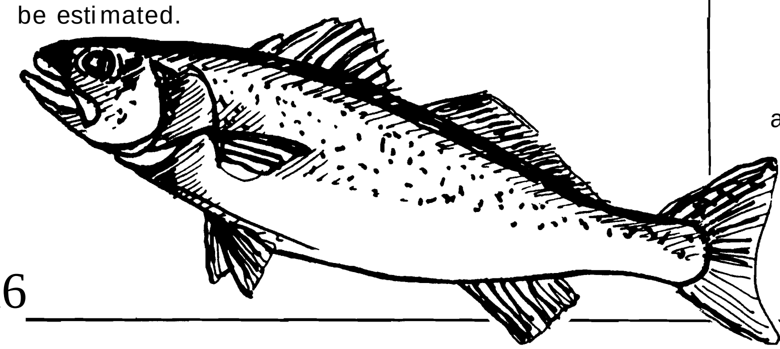


Table 1. Cost of feed in cents to produce a 1-pound fish at different feed conversion rates and feed prices.

	Feed Cost Per Ton				
FCR	$200	$225	$250	$275	$300
1.5	15.0	16.9	18.8	20.6	22.5
1.6	16.0	18.0	20.0	22.0	24.0
1.7	17.0	19.1	21.3	23.4	25.5
1.8	18.0	20.3	22.5	24.8	27.0
1.9	19.0	21.4	23.4	26.1	28.5
2.0	20.0	22.4	25.0	27.5	30.0

Example 1. If 4,000 lbs. of fish were produced per acre, the feed was $250/ton, and the FCR was 1.8, then what is the total cost of feeding these fish per acre?

a. From Table 1, the cost of feed in cents to produce a 1-pound fish with feed at $250/ton and FCR at 1.8 is 22.5¢ or $.225.

4,000 lbs./acre x $.225/lb. = $900/acre

b. If the same fish had a FCR of 2.0 instead of 1.8 with feed at $250/ton, then:

4,000lbs./acre x $.25/lb. = $1,000/acre or $100/acre higher.

c. For a 15-acre pond that means $100/acre difference x 15 acres = $1,500 either saved or spent!

Feed Requirements

The feed requirements for fish change with age, size, health and water conditions. Feeding charts are available for catfish and rainbow trout of different sizes and at different water temperatures.

The following examples illustrate problems and solutions related to feed requirements for fish.

Example 1. A pond is stocked with 45,000 fish that weigh 50 lbs./1,000 fish. The desired feeding rate is 3% of their weight daily. How much feed is needed for 1 day and for 1 week?

$$\text{Note } 3\% = \frac{3}{100} = 0.03$$

a. $\frac{45,000 \text{ fish}}{1,000 \text{ fish}} \times 50 \text{ lbs.} = 2,250$ lbs. of fish stocked

b. 2,250 lbs. x 0.03/day = 67.5 lbs. of feed daily

c. For 1 week: 67.5 lbs./day x 7 days/ week = 472.5 lbs.

Example 2. A 12-acre pond contains 2,000 lbs. of fish per acre. A bacterial disease is diagnosed and double-strength (2 x) Terramycin medicated feed is needed for disease treatment. The daily recommended feeding rate is 1.5% body weight per day for a total of 10 days. How much medicated feed should be ordered and fed to the sick fish?

a. Total pounds of fish in pond:

2,000 lbs./acre x 12 acres = 24,000 lbs. of fish

b. Pounds of medicated feed required per day:

$$\text{Note: } 1.5\% = \frac{1.5}{100} = 0.015$$

24,000 lbs. x 0.015/day = 360 lbs./day

c. Total pounds of medicated feed required for total treatment time of 10 days:

360 lbs./day x 10 days = 3,600 lbs.

d. If feed comes in 50 lb. bags, how many bags of medicated feed are needed?

$$\frac{3,600 \text{ lbs.}}{50 \text{ lbs./bag}} = 72 \text{ bags}$$

Example 3. A fish farm has 45 acres of water. The expected annual average production per acre is 3,500 lbs. of fish. Approximately how much feed will need to be purchased for the year and what will be the total feed cost if feed is expected to cost $240/ton? From past experience the producer expects an FCR of 1.8.

a. Determine the total pounds of fish expected to be produced on the farm for the year.

3,500 lbs./acre x 45 acres = 157,500 lbs. fish

b. Determine the amount of feed required to produce 157,500 lbs. of fish assuming that this weight represents weight gained and not the total weight of fish produced. Remember that the fish weighed something when they were stocked but this initial weight is not taken into account in this example.

$$\text{FCR} \; \frac{\text{Pounds Feed Fed}}{\text{Weight gain of fish}} = 1.8 = \frac{\text{Pounds of Feed}}{157,500 \text{ lbs. weight gained}}$$

Pounds of Feed = 1.8 x 157,500 lbs. = 283,500 lbs.

$$\frac{283,500 \text{ lbs.}}{2,000 \text{ lbs.}} \times 1 \text{ ton} = 141.75 \text{ tons of feed}$$

c. Determine the approximate cost of feeding the fish for the year.

141.75 tons x $240/ton = $34,020

Example 4. To keep pace with the growth of fish, the feeding allowance should be adjusting at least every 2 weeks when fish are feeding well. With this in nlind, what would be the new daily feed allowance of fish in Example 1 after 2 weeks of feeding?

Remember, that fish have gained weight after 2 weeks and the new feed allowance is now based on 3% of the new weight.

New weight = Initial (stocking) weight + weight gained

To estimate the new weight of fish, they can be sampled to determine the average weight of fish and then the total weight, or an expected FCR value can be used. Refer to the section on estimating weight of fish in ponds for more detail.

For this example, an expected FCR of 1.6 will be used to estimate weight gained. The importance of record keeping is obvious because we need to know the amount of feed fed for the 2-week period.

a. 67.5 Ibs/day x 14 days = 945 Ibs. feed fed for 2 weeks

b. $\text{FCR} = \frac{\text{Total Feed Fed}}{\text{Weight gain of fish}}$ 1.6

$\frac{\text{945 Ibs.}}{\text{Weight gain of fish}}$

Weight gain during 2 weeks $\frac{\text{945 Ibs.}}{1.6} = \text{590 Ibs.}$

c. The new daily feed allowance is based on the new fish weight that is the initial weight plus the weight gained during 2 weeks.

2,250 Ibs. + 590 Ibs. = 2,840 Ibs.

2,840 Ibs. x 0.03/day = 85.2 Ibs.Iday new feed allowance

Refer to Table 6 in Appendix for feed consumption rates for different sizes of catfish. These values are only guidelines. Producers should keep adequate records to determine their own figures.

For economic and management reasons, some producers limit the daily feed allowance per water acre. Aeration and risks of fish losses are reduced when the daily feed allowance does not exceed about 100 Ibs./acre. Water quality problems are usually low when feeding rates are below 50 Ibs.lacre/day. With this in mind a producer can determine whether buying bulk feed is feasible based on farm size, storage time and availability of different feed sizes and loads. Table 2 illustrates this situation. You can also use your average feeding rate in place of the maximum feeding rate to determine longer storage periods.

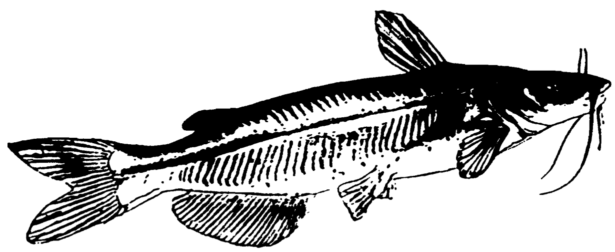


Table 2. Capacity in days of feed for two sizes of bulk storage feed bins for five farm sizes and three feeding -rates.

	Maximum Feeding Rates					
	SO Ibs.lacre/day Bin Size		75 Ibs.lacre/day Bin Size		100 Ibs.lacre/day Bin Size	
Farm Size in Water Acres	10 ton	23 ton	10 ton	23 ton	10 ton	23 ton
15	26.7	61.3	17.8	40.9	13.3	30.7
40	10.0	23.0	6.7	15.3	5.0	11.5
70	5.7	13.1	3.8	8.8	2.9	6.6
100	4.0	9.2	2.7	6.1	2.0	4.6
140	2.9	5.8	1.9	4.4	1.4	3.3

Use the formula below to calculate the feed storage time for your situation:

$$\text{Storage Time in Days} = \frac{\text{Feed bin capacity in pounds}}{\text{Maximum or average feeding rate in lbs./acre/day}}$$

Example 5. The storage time or capacity in days of feed for a 5-acre pond fed at a maximum of 75 lbs./acre/day can be calculated as follows:

a. Determine the maximum feed requirement for 1 day:

5 acres x 75 lbs./acre/day = 375 lbs./day

b. If a person is considering bulk purchase and storage in a 10-ton bin, then the capacity in days for feed is;

10 tons x 2,000 lbs./ton = 20,000 lbs. feed capacity of 10-ton bin

$$\frac{20{,}000\text{ lbs.}}{375\text{ lbs./day}} = 53.3 \text{ days storage time or capacity}$$

This is a long storage time in the bin before new feed is purchased. Storage time should not exceed 30 to 45 days in the summer. For this small farm, bagged feed is recommended to reduce storage time and assure quality and freshness of feed. Refer to Table 7 in the Appendix for a guide to winter feeding of catfish, and note the drastic reduction in feed requirements during the winter.

Fish Stocking Problems---

The number and size of fish stocked in a pond are important. The nurrlber affects the level of management and resources required, and the size influences the length of time needed for fish to reach a desired market size. The following situations are related to stocking fish in ponds. Fish stocking rates are usually based on the surface area of water unless fish are stocked into tanks or raceways with continuous water flow. Refer to Table 8 in the Appendix for weight-length relationships for channel catfish.

Example 1. A pond is 12 acres in size and 4,500 fish per acre is the desired stocking rate. How many fish are needed?

12 acres x 4,500 fish/acre = 54,000 fish

Example 2. A fish farmer wants to stock 60,000 fish in a pond. The fish he wants weigh 45 pounds per 1,000 fish. How many pounds of fish should be stocked?

$$\frac{60{,}000 \text{ fish}}{1{,}000 \text{ fish}} \times 45 \text{ lbs.} = 2{,}700 \text{ lbs.}$$

Example 3. A fish buyer wants to sample some fish from his pond to check the number of fish that he ordered. He samples 150 fish that weigh 9 lbs. The total pounds of fish stocked into his pond was 3,250 lbs. How many fish were stocked?

Number Fish Stocked =

$$\frac{\text{Number Fish in Sample} \times \text{Total Weight Fish Stocked}}{\text{Weight of Sample}}$$

Number Fish Stocked =

$$\frac{150 \text{ fish} \times 3{,}250 \text{ lbs.}}{9 \text{ lbs.}} = 54{,}167 \text{ fish}$$

Example 4. How many pounds of fish are needed to stock 54,167 fish if a sample of 150 fish weighs 9 pounds?

Pounds of Fish Needed =

$$\frac{\text{Total Number of Fish Needed} \times \text{Weight of Sample}}{\text{Number of Fish in Sample}}$$

$$\frac{54{,}167 \text{ fish} \times 9 \text{ lbs.}}{150 \text{ fish}} = 3{,}250 \text{ lbs.}$$

Catfish Stocking Rates

The number of catfish to stock into comnlercial ponds depends on three factors: maximum safe feeding rate, size of fish desired at harvest, and maximum pounds of fish that can be fed at the maximum daily feeding rate. When these factors are considered, a proper stocking rate can be obtained based on economical production and the experience of the producer.

Water quality and frequency of aeration are affected by the daily feeding rate during warmer months. Research has shown that the maximum daily feeding rate should not exceed 100 lbs./acre/day to avoid serious potential water quality problems. Even at this feeding rate, producers should be experienced and have emergency aeration equipment available.

The maximum standing crop or weight of fish per acre can be estimated by knowing the maximum allowable feeding rate and average desired fish size at harvest. By knowing the average fish size at harvest and estimated water temperatures, an estimate of the daily feed consumption rate expressed as a percentage of fish's total weight can be made. With a known daily feed consumption rate (% fish weight), the maximum weight of fish that can be fed within the limit of the maximum feeding rate (lbs.lacre/day) can be determined. The aim is for fish to reach this maximum total weight at about the time of harvest. Overstocked ponds with limits on feeding rates result in underfeeding, less than optimal growth, and longer growout time.

The following examples do not consider variable sizes in fish or differences in growth of individual fish. Also, conditions with different sizes of fish stocked, or ponds harvested periodically (topped), and fish replaced by supplemental stockings are more complex and not addressed in these examples. The examples do illustrate some of the important factors in determining stocking rates. Refer to Tables 6 to 8 in Appendix for information needed to make calculations.

The following maximum feeding rates are recommended to serve as guidelines.

Situation	Maximum Feeding Rate *(lbs.lacre/day)*
Watershed pond without aeration	30
Watershed pond with aeration	60-70
Levee pond with aeration and well	100

Example 1. A fingerling producer wants to grow fish to an average size of 6 inches or 60 lbs./1,000. He does not want to exceed a feeding rate of 100 lbs./acre/day. The estimated feed consumption rate of fish at harvest time is about 3%. How many fish should be stocked?

a. $$\frac{\text{Maximum feeding rate}}{\text{Percent body weight consumed daily}} = \text{Total weight at harvest}$$

$$\frac{\text{100 lbs./acre/day}}{\text{0.03/day}} = \text{3,333 lbs./acre}$$

b. $$\frac{\text{Total weight at harvest}}{\text{Average weight at harvest}} = \text{Fish stocking rate per acre}$$

$$\frac{\text{3,333 lbs./acre}}{\text{0.06 lbs./fish}} = \text{55,550 fish/acre}$$

Example 2. A producer wants to grow catfish to an average weight of 1V4lbs. at harvest and limit maximum feeding rate to 100 lbs./acre/day. He estimates the fish will eat about 1.75% when harvested. How many fish should be stocked per acre?

a. $$\text{Total fish weight} = \frac{\text{100 lbs./acre/day}}{\text{0.0175/day}}$$

$$= \text{5,417 lbs./acre}$$

b. $$\frac{\text{5,714 lbs./acre}}{\text{1.25 lbs./fish}} = \text{4,571 fish/acre stocking rate}$$

In these examples, no adjustment is made for mortality because it can vary and cannot be anticipated. Some producers add an extra 5% or more to the number of fish stocked to adjust for losses based on experience. Future and advances in production practices may demonstrate an economic benefit of increasing feeding rates above 100 lbs./acre/day. The maximum daily feeding rates are guidelines based on present research findings. A complete economic analysis should be made before higher feeding rates are used.

Replacement Stocking After Topping (Partial Harvesting)

It is a common practice for catfish producers to harvest fish from a pond several times during the year. When this is done, fish of a minimum market size are selectively harvested, usually with a $1\frac{3}{8}$ to $1\frac{5}{8}$ inch mesh seine. After harvesting, one fingerling is stocked for each fish harvested. Additional fish should not be stocked until some fish are harvested. This avoids problems with potential overstocking and underfeeding. Multiple harvesting can improve profits for producers, and it assures a needed year-round supply of fish to the processing plants.

Determine the number of fish to restock after partial harvesting by using the formula below. The total weight in pounds of fish harvested from the ponds must be known, and a sample of fish to be harvested must be weighed and counted.

Example 1. A producer harvested 15,000 pounds of fish from a pond. A random sample of 50 fish weighed a total of 55 lbs. How many fish should be stocked to replace those harvested?

Number Fish to Restock

$$\frac{\text{No. fish in sample} \times \text{Total weight harvested (lbs.)}}{\text{Total weight of sample (lbs.)}}$$

$$\frac{\text{50 fish} \times \text{15,000 lbs.}}{\text{55 lbs.}} = \text{13,636 fish}$$

Estimating Numbers of Fry Stock

The growth rate of fish depends much on available food and fish density. The average size of fish obtained at harvest can be planned by adjusting the fish density or stocking rate.

Small, newly hatched fish called fry or seed stock should be stocked at known or estimated numbers. This permits better management, predictable results and the ability to evaluate production efficiency.

The methods and examples given will illustrate how numbers of small fish can be estimated accurately. Because the numbers of fry are so difficult to estimate by simple visual inspection, some method should be used to provide a good, reliable estimate. Small fish double their weight quickly so it is important to make number estimations just before fish are stocked into ponds or troughs.

The volumetric method involves counting a known number of fry and measuring water displacement. First, count 300 to 400 fry and place them in a measured volume of water in a graduated cylinder. Use a sponge to soak up any water from the bottom of fine-mesh dip nets to avoid passing much water with the fish. Determine and record the change in water volume or the amount of water displaced. To determine the total number of fry, place them in a graduated measuring container and record the change in water level. Now use the formula below to estimate the total number of fry.

Total Number of Fry =

$$\frac{300 \times \text{Total water volume change for all fry}}{\text{Water volume change for counted 300 fry}}$$

Example 1. A sample of 300 fry raised the water volume in a 100-milliliter (ml) graduated cylinder -from 50 to 62 ml. A large measuring container graduated in milliliters is used to determine the water volume change for large numbers of fry. In one sample, the water volume changed from 500 ml to 900 ml. How many fry are in this sample?

$$\frac{300 \text{ fry} \times (900 \text{ ml} - 500 \text{ ml})}{62 \text{ ml} - 50 \text{ ml}} \quad \frac{300 \text{ fry} \times 400 \text{ ml}}{12 \text{ ml}} = 10{,}000 \text{ fry}$$

The other method to estimate numbers of seed stock or larger fingerling fish is a weighing method. For fry, weigh a container with water to the nearest gram. A triple-beam gram scale works best for this method. Add 300 to 400 fry and record the increase in weight to the nearest gram. Sponge the bottom of the dip net to soak up any water before placing fish Into weighing container. Next, weigh a container again with only water and record this weight. Place all fry to be counted in this container and record the increase in weight. Use the formula below to estimate the total number of fish.

Total number of fish =

$$\frac{300 \times \text{Weight change with all fish}}{\text{Weight change with 300 fish}}$$

Example 2. A container and water weigh 350 grams. A sanlple count of 300 fish was placed in the weighing container, and the new weight was 370 grams. Next, a larger container with water weighed 900 grams without fish. All fish were put in the weighing container, and the new weight was 1,250 grams. How many total fish were weighed?

a. First, determine the change in weight made by the sample of 300 fish.

For 300 fish:

370 grams weight of container, water and 300 fish
-350 grams initial weight of container and water only
20 grams weight change for 300 fish

b. Determine the weight change for all fish weighed.

1,250 grams weight of container, water and all fish
- 900 grams initial weight of container and water only
350 grams weight change for all fish

c. Now use the formula:

Total Number of Fish =

$$\frac{300 \times \text{Weight change with all fish}}{\text{Weight change with 300 fish}}$$

$$\frac{300 \text{ fish} \times 350 \text{ grams}}{20 \text{ grams}} = 5{,}250 \text{ fish}$$

Estimating Fish Weights in Ponds

Unfortunately, fish spend most of their time under water, and estimating fish weights by observing fish at feeding time is impossible. Yet, fish farmers should know the approximate weight of fish in each pond. If you need to use a medicated feed treatment, then you must know how many pounds of feed to purchase and use. If you do not know the weight of fish, then you may be overfeeding an expensive feed or underfeeding with poor disease control. When fish are near market size, you should know how many pounds of fish you have and their sizes. Problems occur when the producer thinks he has fish of a certain size and fish are harvested and fall short in both weight and number.

If mixed fish sizes occur in a pond, then it is more difficult to keep track of the fish. Again, good record-keeping can help you follow various batches of fish, although a single stock and harvest crop is much easier to follow. The following methods can be used to estimate fish weight in ponds.

Weights by Pond Sampling

To use this method, it is important to keep records of the number of fish stocked and the number of fish lost or harvested. You will need the following equipment to sample and weigh fish:

- A short 50- to 100-foot seine with mesh size to catch smallest fish in the pond.
- A hanging scale that weighs up to at least 50 pounds with increments in ounces.
- Bucket for weighing fish.
- Homemade tripod or bar off truck to hang scale.

The easiest time to sample fish is when they are fed. Throw out a little feed in a corner where fish are normally fed. Pull the seine quickly across the corner to capture the fish. Do not purposely select fish for weighing, because usually the larger fish are selected. Use a dip net and pass through the fish from bottom to top. This should give you a good sample. Count and weigh all fish in the dip net.

Sample the fish during the coolest time of day or when it is overcast to minimize stress. Always move fish in water and handle quickly. Count and weigh three random samples of at least 30 fish per sample or about 90 fish. The more fish you sample, the better the estimate. Compare the average weights from the three samples. They should be similar. If not, then more samples are needed until a consistent value is found in samplings. Mixed fish sizes make this method more difficult to determine an average fish weight. Study the following example:

Example 1: A 15-acre pond was stocked with 67,500 fish. Since stocking, 1,350 fish have died and been recorded. The fish population was sampled. Below is the information that was obtained. What is the estimated standing crop or weight of fish in the pond at the time of the sampling?

Fish sample counts and weights:

Sample 1 - 25 fish weighed 18 lbs. + 10 ozs.
Sample 2 - 30 fish weighed 21 lbs. + 3 ozs.
Sample 3 - 27 fish weighed 18 lbs. + 8 ozs.

Determine the average weight of fish in each sample and compare how similar the weights are.

a. For sample 1, convert ounces to pounds so all weights are in the same units and can be added. One pound equals 16 ounces (ozs.)

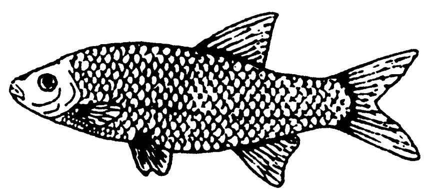
$$18 \text{ lbs.} + 10 \text{ ozs.} = 18 \text{ lbs.} + \frac{10 \text{ ozs.}}{16 \text{ ozs.}} \times 1 \text{ lb.}$$

$$18 \text{ lbs.} + 0.625 = 18.625 \text{ lbs.}$$

b. Determine the average weight of fish in sample 1.

Average Fish Weight

$$\frac{\text{Weight in pounds}}{\text{Fish in sample}} \quad \frac{18.625 \text{ lbs.}}{25 \text{ fish}} \quad 0.745 \text{ lbs. per fish}$$



c. Repeat for samples 2 and 3.

For **Sample 2:**

Average Fish Weight =

$$\frac{21.19 \text{ lbs.}}{30 \text{ fish}} = 0.706 \text{ lbs. per fish}$$

For **Sample 3:**

Average Fish Weight =

$$\frac{18.5 \text{ lbs.}}{27 \text{ fish}} = 0.685 \text{ lbs. per fish}$$

d. The average weights of fish in each of the three samples are similar, so now determine the average weight of all fish together for the three samples.

Sample Number		Number of Fish	Total Weight (lbs.)
1		25	18.625
2		30	21.19
3		27	18.5
	Totals	82 fish	58.315 lbs.

Average fish weight =

$$\frac{\text{Total pounds}}{\text{Total number}} \quad \frac{58.315 \text{ lbs.}}{82 \text{ fish}} = 0.71 \text{ lbs.}$$

e. To estimate the standing crop of fish in the pond, do the following:

Total Fish Weight =

Average Weight of Fish x Number of Fish in Pond

Total Fish Weight = 0.71 lbs./fish x (fish stocked - fish lost or harvested)

= 0.71 lbs./fish x (67,500 fish - 1,350 fish)

= 0.71 lbs./fish x 66,150 fish

Total Fish Weight = 46,966 lbs.

Weights from Feed Records

You can also estimate the pounds or weight of fish in a pond by knowing the amount of feed you have fed fish. You also need to know the initial weight of fish and have a good idea of what the feed conversion ratio is for your fish at the time of standing crop estimation.

The basis for the estimation is using the formula below. The following example illustrates how the method is used.

$$\text{Feed Conversion Ratio} = \frac{\text{Pounds Feed Fed}}{\text{Weight Gain of Fish}}$$

Example 2. A pond was stocked with 30,000 fish that weighed 70 lbs. per 1,000 fish. During a period of time, the fish were fed 2,500 lbs. of feed and no losses were observed. What is the estimated total weight of fish in the pond? Assume that the feed conversion ratio was 1.7.

a. Determine the initial weight of fish in the pond or the weight since the last sampling:

$$\frac{30{,}000 \text{ fish}}{1{,}000 \text{ fish}} \times 70 \text{ lbs.} = 2{,}100 \text{ lbs. initial weight}$$

b. Use the feed conversion ratio formula and your values:

$$\text{Feed Conversion Ratio} = \frac{\text{Pounds Feed Fed}}{\text{Weight Gain of Fish}}$$

$$1.7 = \frac{2{,}500 \text{ lbs. feed}}{\text{W (Estimated weight gain)}}$$

To make the calculation easier, use the following steps:

1. Divide 1.7 by 1: $\frac{1.7}{1} \quad \frac{2{,}500 \text{ lbs.}}{\text{W(?)}}$

2. Cross multiply the numbers across the = sign:

$\frac{1.7}{1} \quad \frac{2{,}500 \text{lbs.}}{\text{W}}$ becomes 1.7 x W = 1 x 2,500 lbs.

3. Divide each side of = sign by 1.7:

$$\frac{1.7 \times W}{1.7} \quad \frac{2{,}500 \text{ lbs.}}{1.7} \text{ becomes } W = 1{,}479 \text{ lbs.}$$

c. Estimate the total weight of fish in the pond:

Total Weight = Initial Weight + Weight Gained

Total Weight = 2,100 lbs. + 1,470 lbs.

Total Weight = 3,570 lbs.

By making this calculation each week or two, you can estimate the new fish weight gain in the pond and adjust your feeding allowance to keep up with the growth of fish. This way you are not grossly underfeeding your fish and slowing their rate of growth.

What would have been the results of Example 2 if you used different values for your feed conversion ratio? The weight gain was 1,470 lbs. with an FCR of 1.7. The following differences would occur:

Feed Conversion Ratio Used	Weight Gain in Lbs. For Example 2
1.6	1,562
1.8	1,389
1.9	1,316
2.0	1,250

You can see how much the weight gain value is changed by using different values for the feed conversion ratio. To estimate fish weights in ponds, the best practice is to use the feed conversion ratio method to increase the weight of fish each week.

Use this new weight to adjust your feeding allowance quickly. Every four to six weeks, sample the fish in your ponds to determine the average weight of fish and estimate the total weight of fish. Compare the values from the two methods, remembering that if your fish are similar in size, the pond sampling method gives you the best estimate.

Pounds of Harvestable Fish

Unfortunately, in fish culture you cannot see your crop like most other agricultural commodities. For this reason, periodic sampling of fish is important to adjust feed allowances, check fish growth, and general condition and health of fish. It is important for producers to follow the growth rate of fish and know when fish will reach a marketable size.

The producer needs to know when it is economical to harvest fish, and the procesing plant needs the pounds and sizes of fish that are booked for delivery. The seller needs to know what he has to sell, and the buyer needs to get what he wants.

To help determine the pounds of harvestable size catfish in a pond with mixed sizes, refer to the form in Table 9 of the Appendix. The approximate number of fish in the pond needs to be known. You simply record the lengths of fish sampled in inches, total the number of fish for each inch group and multiply each total by the average individual weight for each inch group. Next, total all fish sampled and add up all weights. Follow formulas and example below to calculate harvestable pounds of fish in the pond. When measuring fish, a 6-inch fish is a fish between the lengths of 5Y2 and 6Y2 inches.

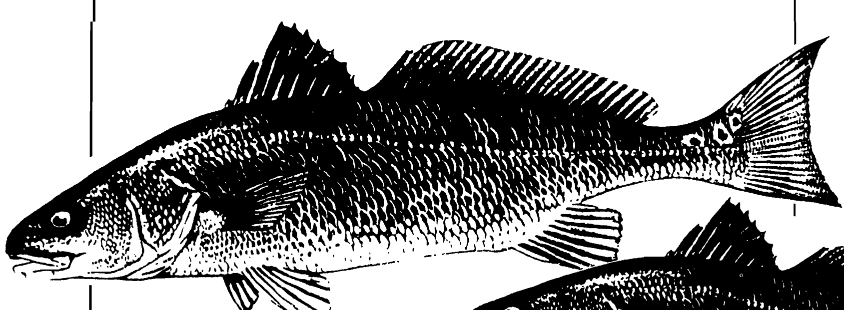
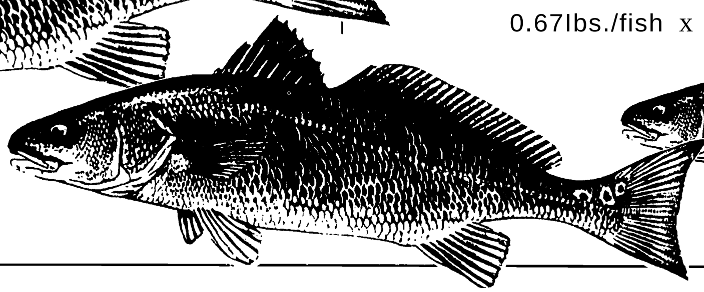
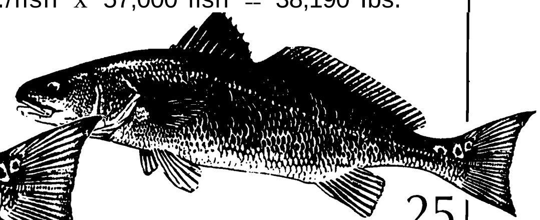
Example 1. A total of 135 fish were measured for individual lengths and weights by each inch group were recorded. The total weight of fish sampled was 90 lbs. About 57,000 fish are in the pond. Minimum acceptable harvest weight is 0.75 lbs. Forty-five fish in the sample of 135 fish were 0.75 lbs. or larger and they weighed 56 lbs. How many pounds of fish in the pond are of harvestable size?

a. $\frac{\text{Total weight of fish sample (lbs.)}}{\text{Total number of fish sampled}} = \text{Average weight per fish}$

$$\frac{90 \text{ lbs.}}{135 \text{ fish}} = 0.67 \text{ lbs./fish}$$

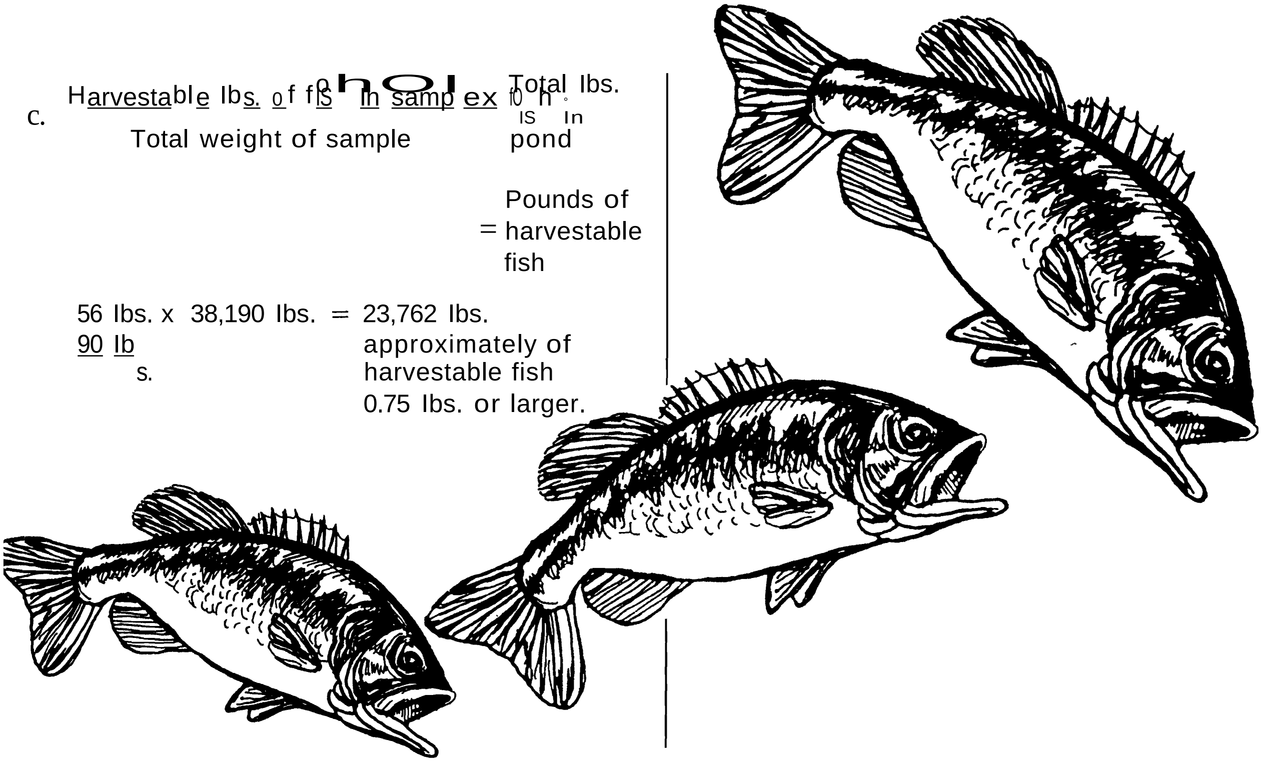
b. Average weight/fish x Total fish in pond = Total lbs. fish in pond

0.67 lbs./fish x 57,000 fish = 38,190 lbs.

c. $\frac{\text{Harvestable lbs. of fish in sample}}{\text{Total weight of sample}}$ x Total lbs. of fish in pond = Pounds of harvestable fish

$\frac{56 \text{ lbs.}}{90 \text{ lbs.}}$ x 38,190 lbs. = 23,762 lbs. approximately of harvestable fish 0.75 lbs. or larger.



Brood Fish and Facility Requirements

Planning is an important part of aquaculture, and producers should plan their production based on available facilities. Sometimes, in seed stock production, too many fish are producedo That can cause overcrowding, disease, slower fish growth and economic losses. Also, large brood fish are expensive to maintain because they occupy pond space and convert feed poorly as they gain weight.

With good planning, facilities can be used efficiently, and production goals can be achieved. The following describes a guideline for determining brood fish and facility needs based on a desired production goal of fingerling or stocker fish. To use this method, you need to have reliable baseline information that reflects YOUR situation because estimating values can vary, depending on experience and accuracy of information collected.

The following example will serve as a guide.

Example 1. A catfish fingerling producer wants to produce 800,000 fingerlings that average about 4 to 6 inches in length. He wants to know how many acres of ponds will be needed to produce these fish and how many pounds of male and female brood fish are required.

a. The following assumptions are based on experience and published information:

1. Brood fish are stocked at a maximum of 1,200 lbs. per acre with a male: female ratio of 2:3, or 2 males for each 3 females.
2. 50% of female brood fish will lay eggs (spawn).
3. Each spawning female fish will produce 2,600 eggs per pound of body weight.
4. The survival of eggs during hatching is 95%.
5. The survival of fry to 4-6 inches in length is 70%.
6. The maxinlum stocking rate of fry "to reach an average of 4 to 6 inches after 120 to 150 days of culture is 75,000/acre.

b. To estimate the number of fry needed, use the following calculation:

Number fry needed = $\dfrac{\text{Number of fingerlings desired}}{\text{Percent fry survival expressed as a decimal}}$

Given: 70% fry survival = $\dfrac{70}{100}$ = 0.70

Number of fry needed = $\dfrac{800{,}000 \text{ fingerlings}}{0.70}$ = 1,142,857

c. The number of acres of fingerling ponds needed will be:

$\dfrac{\text{Total fry stocked}}{\text{Recommended number/acre}}$ = Number of water acres required to produce fish of a desired size

$\dfrac{1{,}142{,}857 \text{ fry}}{75{,}000 \text{ fry/acre}}$ = 15.24 acres of fingerling rearing ponds

d. Use the below calculations to determine the pounds of brood fish needed:

1. Number of eggs needed = $\dfrac{\text{Number fry required}}{\text{Percent survival for eggs expressed as a decimal}}$

Given: 95% egg hatching success = $\dfrac{95}{100}$ = 0.95

Determined: 1,142,857 fry needed

Number eggs needed = $\dfrac{1{,}142{,}857 \text{ fry}}{0.95}$ = 1,203,007

2. Given: Each spawning female produces 2,600 eggs per pound of body weight

Number of pounds of spawning females = $\dfrac{\text{Number of eggs required}}{\text{Egg production/pound body weight}}$

= $\dfrac{1{,}203{,}007 \text{ eggs}}{2{,}600 \text{ eggs/lb.}}$ = 463 lbs. of female brood fish

3. Given: Only 50% of female brood fish spawn successfully during spawning season, so the pounds of females must be increased (doubled).

Total pounds of female brood fish required = Pounds of spawning females x $\dfrac{100\%}{\text{Percent of females that spawn}}$

= 463 lbs. x $\dfrac{100\%}{50\%}$ = 926 lbs. female brood fish

e. How many female brood fish would be required if they averaged 4 pounds each and how many male brood fish would be required in the spawning pond?

1. Total number of female brood fish = $\dfrac{\text{Total pounds needed}}{\text{Average weight/fish}}$

$\dfrac{926 \text{ lbs.}}{4 \text{ lbs./fish}}$ = 231 females

2. To determine the number of male brood fish required, it is given that 2 males should be used for every 3 females.

$\dfrac{231 \text{ females}}{3 \text{ females}}$ x 2 males = 77 x 2 males

= 154 males needed

f. If the female brood fish weigh a total of 926 lbs. and the male brood fish average about 4.5 pounds each, then how many acres of water are needed for spawning?

Given: Recommended maximum stocking rate of 1,200 lbs./acre for brood fish.

1. Determine pounds of male brood fish:

Total pounds = Total number x Average weight/fish of male fish

= 154 males x 4.5 lbs./male = 693 lbs.

2. Determine total pounds of brood fish:

Total pounds = Total lbs. females + Total lbs. males brood fish

= 926 lbs. + 693 lbs. = 1,619 lbs.

3. How many acres of water are needed in spawning ponds?

$\dfrac{\text{Total brood fish lbs.}}{\text{Recommended lbs./acre}}$ = Number of water acres (minimum)

$\dfrac{1{,}619 \text{ lbs.}}{1{,}200 \text{ lbs./acre}}$ = 1.35 acres minimum

Calculating Treatments

Most aquaculture systems including ponds, tanks and raceways eventually will require some type of chemical treatment to combat a disease or aquatic plant problem or improve water quality conditions. Some treatments, like fertilizers or lime, are based on the surface area of water, but most treatments include the total volume of water in the production or holding unit.

All commercial aquaculturists should know how to calculate treatment rates, determine the amount of chemical or material needed, and apply the treatment. Before any treatment is applied, the water, fish, chemical, condition of the problem and method of treatment should be known and understood. Producers can experience high economic losses when treatment rates are not properly calculated.

Before any calculation is made, the units of measurements should be determined. The unit of measurement selected should be one familiar to you and convenient for the specific situation. For example, the large volume of water in ponds is usually expressed as acre-feet, while the volume of a small tank may be expressed in gallons or cubic feet. Another decision is whether to use the English or metric system of measurement. A working knowledge of both systems is important because reports or publications may use either one. Metric units are easiest to work with when small volumes or weights are involved.

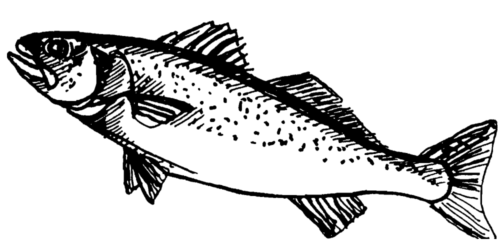
To make calculations easy, refer to Table 10 for conversion factors and parts per million equivalents.

The Basic Formula

Most treatments can be calculated using this basic formula:

$$\text{Amount of chemical needed} = V \times C.F \times \text{ppm desired} \times \frac{100}{\%AI}$$

Where: V = The volume of water in the unit to be treated.



C.F. = A conversion factor that represents the weight of chemical that must be used to equal one part per million (1 ppm) in one unit of the volume (V) of water to be treated. The unit of measurement for the results is the same as the unit used for the C.F.(pounds, grams, etc.). Table 10 in Appendix contains a list of these conversion factors for various units.

ppm = The desired concentration of the chemical in the volume (V) of water to be treated expressed in parts per million.

$\frac{100}{\%AI}$ = 100 divided by the percent active ingredient contained in the chemical to be used. Most chemicals are 100% A.1. unless otherwise specified so this value is usually 1. The percent A.I. is usually found on the label of most fisheries chemicals.

To understand how the basic formula is used to calculate treatments, review the following examples that represent a variety of practical situations.

Example 1. How much copper sulfate is needed to treat a 10-acre pond with an average water depth of 4 feet with a 1.3 ppm treatment?

a. Select the unit of measurement and then determine the volume of water in the pond. Volume (V) of water in the pond can be expressed as acre-feet.

10 acres x 4 feet = 40 acre-feet

b. The conversion factor (C.F.) for acre-feet is found in Table 10 and is 2.7 pounds. This weight is required to give 1 ppm in 1 acre-foot of water.

c. The parts per milHon (ppm) or concentration of copper sulfate desired is 1.3.

d. Copper sulfate is 100 percent active (A.I.) so when 100 is divided by 100 the result is 1.

e. The amount of copper sulfate needed is determined by using the correct numbers in the basic formula as follows:

Weight of chemical needed

$$V \times C.F. \times \text{ppm desired} \times \frac{100}{\%AI}$$

lbs. of copper sulfate = 40 acre-feet x 2.7 lbs. x

$$1.3 \text{ ppm} \times \frac{100}{100} = 140.4 \text{ lbs.}$$

Example 2. Not all fishery chemicals are 100% active ingredient, and some chemicals are only approved for non-food fish, like bait minnows. One such product is Masoten. It contains 80% active ingredient. How much Masoten is needed to treat a pond that has 8 acres of water and an average depth of 3½ feet with 0.25 ppm active ingredient?

a. The volume (V) of water in pond expressed in acre-feet is:

8 acres x 3.5 feet average depth = 28 acre-feet

b. The conversion factor (C.F.) for acre-feet is 2.7 (Table 10).

c. The concentration of Masoten desired is 0.25 ppm active ingredient (ppm desired).

d. Masoten contains 80% material as active ingredient (%A.I.) so 100 divided by 80 equals 1.25.

The amount of Masoten required is determined as follows:

Weight of chemical needed =

$$V \times C.F. \times \text{ppm desired} \times \frac{100}{80}$$

28 acre-feet x 2.7 lb. x 0.25 ppm x 1.25

= 23.6 lbs. of Masoten

Example 3. How much formalin is needed to treat a holding tank that is 20 feet long by 4 feet wide and has a water depth of 2½ feet with 250 ppm?

a. Determine volume (V) of water in tank by multiplying length x width × depth in feet.

Volume in cubic feet = 20 ft. x 4 ft. x 2.5 ft. = 200 cubic feet

b. The conversion factor (C.F.) for cubic feet is 0.0283 grams (Table 10), or the weight of chemical needed to give 1 ppm in 1 cubic foot of water.

c. The parts per million (ppm) desired is 250.

d. Formalin is regarded as 100 percent active (A. I.) for treatment purposes, so 100 divided by 100 equals 1.

Formalin needed = 200 ft.^{3} x 0.0283 grams x 250 ppm x 1 = 1,415 grams

Formalin is a liquid, therefore, the unit of weight in grams must be converted to a volume unit. This is done simply by dividing the results, 1,415 grams, by 1.08 which is the specific gravity of formalin.

$$\frac{1{,}415 \text{ grams}}{1.08 \text{ grams/cm}^3} = 1{,}310 \text{ cubic centimeters (cm}^3\text{)}$$

To convert cubic centimeters to another unit of volume for measuring in fluid ounces, refer to Table 15. Multiply the conversion factor of 0.0338 x 1,310 cm^3 to obtain volume in fluid ounces, 44.3 fl. oz.

Example 4. How much potassium permanganate is needed to treat a circular tank that is 6 feet in diameter and has a water depth of 4 feet with 10 ppm?

a. Volume of circular tank is: V = 3.14 x r^2 x d
Volume = 3.14 x (3 feet x 3 feet) x 4 feet = 113 cubic feet

b. Conversion factor (C.F.) for cubic feet is. 0.0283 grams.

c. The desired ppm is 10.

d. Potassium permanganate is considered to be 100% A.1.

The values are simply substituted into the basic formula to obtain grams of potassium permanganate needed:

$$113 \text{ cubic feet} \times 0.0283 \text{ grams} \times 10 \text{ ppm} \times \frac{100}{100}$$

= 32 grams

Copper Sulfate

Copper sulfate (commonly called copper or bluestone) is used in aquaculture production to control certain types of algae and external parasites. When using copper sulfate, the treatment rate should be determined by knowing the total alkalinity of the water to be treated. The toxicity of copper sulfate to fish varies, depending on the alkalinity of water.

The toxicity to fish increases as alkalinity decreases, and low alkaline waters less than 50 ppm have a narrow margin of safety for fish when copper sulfate is used. In low alkaline waters, a bioassay should be done before a pond is treated to reduce risk of fish losses, or a substitute chemical treatment should be used. The effectiveness of copper sulfate may be lowered when it is used in waters with alkalinities above 350 to 400 ppm because of the fast precipitation of copper from the pond water.

Use the following formula to determine the treatment rate of copper sulfate in ppm when the total alkalinity of water to be treated is known. Total alkalinity is expressed in ppm as calcium carbonate.

$$\text{ppm Copper Sulfate} = \frac{\text{Total alkalinity (ppm)}}{100}$$

Example 1. A pond contains 25 acre-feet of water and has a total alkalinity of 150 ppm. How many pounds of copper sulfate are needed to control a parasite problem?

a. Determine treatment rate of copper sulfate in ppm.

$$\text{ppm Copper Sulfate} = \frac{\text{Total alkalinity}}{100} = \frac{150}{100} = 1.5$$

b. Determine how many pounds of copper sulfate are needed to treat the pond at the rate of 1.5 ppm. Use the basic treatment formula.

$$\text{Amount of copper sulfate needed} = V \times C.F. \times \text{ppm desired} \times \frac{100}{\%A.I.}$$

$$= 25 \text{ acre-feet} \times 2.7 \text{ lbs.} \times 1.5 \text{ ppm}$$

$$\times \frac{100}{100} = 101.25 \text{ lbs.}$$

Potassium Permanganate in Ponds

Potassium permanganate is a chemical commonly used in many aquaculture situations to treat a variety of fish diseases. When applied to ponds, treatments may not be successful or are wasted because of the fast breakdown of the chemical caused by a reaction with organic matter in the pond water. It is also an expensive treatment, and knowing the amount needed and cost prior to treatment is important for management and decision-making.

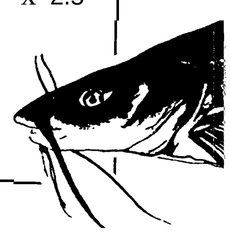
Earlier recommendations were to add the chemical at the rate of 2 ppm and apply subsequent similar applications to maintain a reddish color in the water for 8 to 12 hours. This is difficult, especially when darkness occurs, and treatment costs can be excessively high in ponds with high amounts of organic material. The treated water changes from a reddish, wine-red color to dirty brown when the chemical breaks down and loses its activity.

A simple method and calculations can be used to estimate the amount of potassium permanganate needed for different pond conditions. It involves determining the 15-minute potassium permanganate demand, then multiplying this value by 2.5 to estimate the treatment rate. To determine the 15-minute demand for the chemical: 1) prepare a 1,000 mg/liter stock solution of potassium permanganate by adding 1,000 milligrams or 1 gram of the chemical to 1 liter of distilled water, 2) prepare a series of five or six samples of pond water to be treated each containing 1.0 liter of water, 3) prepare a series of treatments, like 2, 4, 6, 8 and 10 mg/liter of potassium permanganate by adding 1 ml of the stock solution for each mg/l desired, and 4) wait 15 minutes. The lowest treatment rate that still has a faint pink color determines the 15-minute potassium permanganate demand.

Example 1. A series of 1.0 liter pond samples was treated with potassium permanganate stock solution, and after 15 minutes the lowest treatment rate still having a faint pink color was 4 mg/liter. What concentration of potassium permanganate in ppm is required to treat the pond?

$$\text{Potassium permanganate treatment rate (ppm)} = \text{15-minute demand value} \times 2.5$$

$$= 4 \text{ ppm} \times 2.5 = 10 \text{ ppm}$$



Salt Calculations

Salt is used often in the aquaculture industry. It is used to raise chloride levels in ponds to combat problems associated with high nitrite levels (brown blood disease), and it is often used in fish transport tanks. Recent work with redfish has suggested that chloride levels should be at least 300 ppm for good survival and growth. Salt is also known as sodium chloride.

Nitrite Management

To calculate the amount of salt needed in a pond with detectable nitrite concentrations, use the formula below. Salt produces a source of chloride equivalent to 1 ppm when 4.5 lbs. are added per acre-foot of water.

(5 x N) - C = concentration of chloride needed in ppm

Where: N = parts per million (ppm) of nitrite in pond water

C = parts per million of chloride in pond water

Example 1. A water sample contai"ns 4 ppm nitrite and 15 ppm chloride. How much salt is needed to treat an 8-acre pond with an average water depth of 6 feet?

a. (5 x N) - C = ppm chloride needed
(5 x 4) - 15 = 20 - 15 = 5 ppm chloride

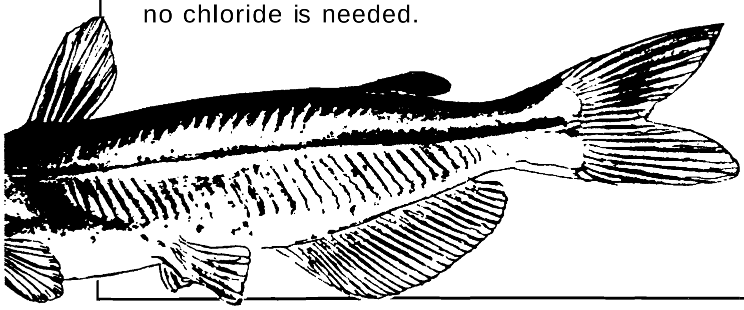
b. To determine the amount of salt needed, use the basic formula, but substitute 4.5 lbs. for the C.F. because this much salt gives 1 ppm chloride per acre-foot.

$$\text{V x C.F. x desired ppm x } \frac{100}{\%\text{AI}} = \text{Amount of material needed}$$

$$\text{(8 acres x 6 feet) x 4.5 lbs. x 5 ppm x } \frac{100}{100}$$

48 acre-feet x 4.5 lbs. x 5 ppm x 1 = 1080

If the answer is zero or a negative nurnber, then no chloride is needed.



Tra.nsport Fish

Salt can be used when transporting many species of freshwater fish. Before large numbers of any species are hauled without knowing the tolerance level of the species, a trial run or test should be conducted that simulates the length of the trip and evaluates different salt concentrations under the conditions fish will be hauled. Salt is usually added to give a concentration of 0.1 to 0.3% or 1,000 to 3,000 ppm salt.

Example 1. A transport tank contains 125 gallons of water. How much salt is needed to give a concentration of 0.2% in the hauling water?

a. Sometimes it is confusing to change from one unit to another. In this example, it is easiest to change 0.2% to ppm, then use the basic formula.

$$0.2\% = \frac{.2}{100} ; \frac{.2}{100} \text{ x } \frac{10,000}{10,000}$$

$$\frac{2,000}{1,000,000} = 2,000 \text{ ppm}$$

b. Now use the basic formula. Remember, in this case the ppm desired is salt or sodium chloride, not just chloride as in the previous example.

$$\text{V x C.F. x ppm desired x } \frac{100}{\%\text{A.I.}} = \text{Amount salt needed}$$

125 gallons x 0.0038 grams x 2,000 ppm

$$\text{x } \frac{100}{100} = 950 \text{ grams}$$

c. To convert grams to ounces or pounds, simply refer to Table 15.

950 grams x 0.0353 = 33.5 oz.
950 grams x 0.0022 = 2.09 lbs.

d. The amount of salt needed can be determined by calculating the weight of water and then determining the concentration of salt desired on a weight per weight basis as follows. One gallon of water weighs 8.34 lbs. and 0.2% equals 0.002.

1. 125 gallons water x 8.34 lbs./gallon = 1,042.5 lbs. water
2. 0.002 x 1,042.5 lbs. = 2.09 lbs. of salt.

Removal of Chlorine

Chlorine is toxic to fish at low concentrations and sometimes needs to be removed when fish are held in tanks supplied by chlorinated city water. The residual chlorine level normally found in municipal water supplies ranges from 0.5 to 2 ppm. Mechanical aeration and exposure to sunlight both reduce chlorine levels, but the most effective method to remove chlorine quickly is treatment with sodium thiosulfate.

To calculate the amount of sodium thiosulfate needed to neutralize the chlorine, first determine the amount of chlorine found in the water. Portable test kits can be used to determine chlorine concentratjons. Next, 7.4 ppm of sodium thiosulfate is needed for each 1 ppm chlorine in the water.

Example 1. Water in a tank contains 1.5 ppm chlorine. How many ppm of sodium thiosulfate is needed to neutralize the chlorine?

$$1.5 \text{ ppm chlorine} \times \frac{7.4 \text{ ppm sodium thiosulfate}}{1 \text{ ppm chlorine}} = 11.1 \text{ ppm sodium thiosulfate}$$

Exa.mple 2. How many grams of sodium thiosulfate are needed if the tank in example 1 contains 350 gallons of water?

Use the basic treatment formula:

$$350 \text{ gal.} \times 0.0038\text{gm.} \times 11.1 \text{ ppm} \times 1 = 14.80 \text{r } 15 \text{ grams}$$

Refer to Example 5 in the section on constant-flow treatments for an example of removing chlorine in a continuous water flow facility.

Rotenone Trea'tment and Detoxification

Rotenone is a product extracted from the roots of several tropica! plants. It is widely used as a fish toxicant. Rotenone is available in both powder and liquid formulations. The dosage rate depends on the intended purpose and species of fish desired to eliminate. Some fish, like large bullheads or mudcats, can be difficult to control with rotenone. Fish eggs are more resistant to rotenone than are fish. Treatment is best at temperafures above 60°F and when nuisance fish are not spawning. Rotenone inhibits cellular respiration of fish, which causes death. It enters fish easily across the gills.

Rotenone treatment rates are reported as both commercial product and active ingredient. For example, 5% rotenone powder contains 5% active ingredient of rotenone by weight. A 1 ppm treatment of 5% rotenone is 2.72 lbs./acre-foot that is equivalent to 0.13 lbs. of actual rotenone per acre-foot or 0.05 ppm.

Below are guidelines in Tables 3 to 5 for using rotenone in various pond situations. To be on the safe side, the higher treatment rate is recommended.

Table 3. Treatment Rate for 5% Powder Rotenone

Pond Situation	5% Rotenone (ppm)	Active Ingredient Equivalent (ppm)
Normal Pond Use	0.5 - 1.0	0.025 - 0.05
Remove Bullheads/ Carp	1.0 - 2.0	0.05 - 0.10

Table 4. Treatment Concentrations in ppm for 5% Liquid Rotenone

Quantity Applied	Volume of Water (acre-feet)	Treatment Concentration as Commercial Product
1 gallon	6	0.5
1 gallon	3	1.0
1 gallon	1½	2.0

Table 5. Standard Treatment Rates for Different Rotenone Formulations.

Rotenone Formulation	Quantity per acre-foot	Treatment Rate Commercial Product (ppnl)	Concentration (ppm) Active Ingredient
5% Powder	3 lbs.	1.1	0.05
5% Liquid	3 pts.	1.1	0.05
2.5% liquid	6 pts.	1.1	0.05

Example 1. A pond is drained to reduce the volume of water and eliminate fish using 5% rotenone powder. The pond contains 15 acre-feet of water and only scaled fish. How much rotenone is needed?

a. For normal pond, 1.0 ppm of 5% rotenone powder is recommended. Commercially available 5% rotenone is considered to be 100% A.1.

b. Use the basic treatment formula.

$$\text{Amount of 5\% rotenone powder} = V \times \text{C.F.} \times \text{ppm desired} \times \frac{100}{\%\text{A.I.}}$$

$$= 15 \text{ acre-feet} \times 2.7 \text{ lbs.} \times 1 \text{ ppm} \times \frac{100}{100} \quad 40.5 \text{ lbs.}$$

Example 2. The above problem can also be solved by using the ppm of A.I. recommended that is 0.05 ppm. In this case 5% rotenone is not 100% A.I., but only 5%.

Amount of 5% rotenone powder = V x C.F.

x ppm desired x $\frac{100}{\%A.I.}$ = 15 acre-feet x 2.7 lbs.

x .05 ppm x $\frac{100}{5}$ = 40.5 lbs.

Example 3: A pond contains 10 acre-feet of water and has carp that need to be eliminated. Liquid 5% rotenone will be used. How many gallons are needed?

a. Because carp are in the pond, the treatment rate of 0.10 ppm active ingredient is recommended. From Table 5, 3 pints of 5% liquid rotenone per acre-foot equal 0.05 ppm active ingredient.

$\frac{0.10 \text{ ppm desired}}{0.05 \text{ ppm}}$ x 3 pints = 6 pints per acre-foot for 0 10 ppm active ingredient treatment

b. Determine amount of 5% liquid rotenone needed to treat 10 acre-feet of water at a rate of 0.10 ppm active ingredient.

10 acre-feet x 6 pints/acre-foot = 60 pints of 5% liquid rotenone

c. Convert fluid pints to gallons using Table 15 in Appendix.

60 pints x 0.125 = 7.5 gallons of 5% Liquid Rotenone needed

Rotenone detoxifies or breaks down eventually in pond waters. Breakdown occurs fastest at high temperatures and conditions of intense sunlight. For quick detoxification of rotenone, potassium permanganate can be used at the rate of 5.4 lbs. for each 2.7 lbs of 5% powdered rotenone or 3 pints of 5% liquid rotenone per acre-foot (2 ppm: 1 ppm). Table 6 gives the breakdown time for normal rotenone treatment at different water temperatures. It is only a guide. Live fish should be caged and placed in treated water for 24 to 48 hours to evaluate toxicity of water before large numbers of fish are stocked.

Table 6. Approximate Breakdown Time for Rotenone Used at 0.05 ppm A.1.

Water Temperature of	0C	Approx. Number of Days to Disappear
50	10	26
60	16	14
70	21	7
80	27	4

Example 3. A pond containing 6-acre feet of water is treated with 18 lbs. of 5% rotenone powder. How much potassium permanganate is needed to detoxify this rotenone treatment?

a. Determine the treatment rate of rotenone as commercial product in ppm. Use the basic treatment formula and solve for ppm:

18 lbs. of 5% rotenone = V x C.F. x

ppm treated x $\frac{100}{100}$

18lbs. = 6 acre-feet x 2.7 lbs. x

ppm treated x 1

$\frac{18\text{lbs.}}{6 \text{ acre-feet x } 2.7 \text{ lbs.}}$ 1.1 ppm 5% rotenone treatment

b. To detoxify rotenone, potassium permanganate is used at the rate of 2 ppm for each 1 ppm of 5% powdered rotenone.

$\frac{1.1 \text{ ppm}}{1.0 \text{ ppm}}$ x 2 ppm = 2.2 ppm potassium permanganate needed

c. Solve for pounds of potassium permanganate needed to treat 6 acre-feet of water at 2.2 ppm

Amount of potassium permanganate =

V x C.F. x ppm desired x $\frac{100}{\%A.I.}$

= 6 acre-feet x 2.7 x 2.2 ppm x $\frac{100}{100}$ = 35.6 lbs.

Aquatic Herbicides

Aquaculturists need to know how to calculate treatments using various types of aquatic herbicides. The recommended dosage to control a particular aquatic plant is found on the product label. Aquatic herbicides occur in various formulations including liquids, wettable powders and granules. The liquid herbicides are usually diluted with water prior to usage. The following examples illustrate how to calculate treatments using various aquatic herbicides under different conditions. The use of product names implies no endorsement nor any intentional exclusion of any products not mentioned. Always properly identify nuisance weeds, and read product label thoroughly before buying and using any aquatic herbicide. Some water use restrictions may exist. Product should be approved for use in aquatic sites and for food fish if they are in pond to be treated.

Example 1. A pond owner desires to use Rodeo as a foliar spray to control cattails. He wants to apply a *1V2%* solution in a 3-gallon pump sprayer. He also needs to add X-77 Spreader as a wetting agent at a rate of *V2%* solution. How many ounces of Rodeo and X-77 Spreader are required? Given: 1 gallon = 128 fluid ounces.

a. Determine the number of fluid ounces in the 3-gallon sprayer:

3 gal. x 128 ounces/gal. = 384 ounces

b. Determine *1V2%* of volume capacity to calculate ounces of Rodeo needed:

$$1V2\% = \frac{1.5}{100} = 0.015$$

384 ozs. x 0.015 = 5.76 or 6 ozs. of Rodeo

c. Determine *V2%* of volume capacity to calculate ounces of X-77 Spreader needed:

$$V2\% = \frac{.5}{100} = 0.005$$

384 ozs. x 0.005 = 1.9 or 2 ozs. of X-77 Spreader

Example 2. Granular 2, 4-D will be used to control lily pads in a pond. The pond is 3½ acres and one-half of the pond is infested with water lilies. The recommended treatment rate is 100 pounds per surface acre. How many pounds of 2, 4-D granules are needed?

a. The area to be treated is one-half the pond area:

0.5 x 3.5 acres = 1.75 acres to treat

b. Amount of material needed:

100lbs./acre x 1.75 acres = 1751bs. of granular 2,4-D.

Example 3. A 5-acre pond is infested with several aquatic weeds, and Aquazine will be used to control them. The recommended dosage is 3 pounds per acre-foot of water. The average water depth in pond is *4V2* feet. How many pounds of Aquazine are required for treatment?

a. Determine the acre-feet of water in pond to be treated.

5 acres x 4.5 feet depth = 22.5 acre-feet

b. Calculate pounds of Aquazine needed:

3 lbs./acre-foot x 22.5 acre-feet = 67.5 lbs. of Aquazine

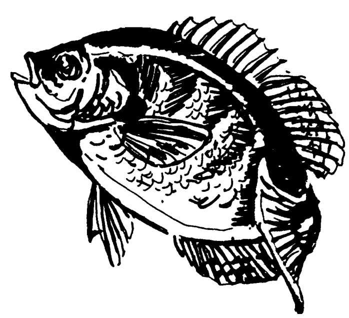
Example 4. About one-fourth of the area in a 8-acre pond has southern naiad (najas). The average depth of water in the weed-infested area is 4 feet. Diquat is desired for control at the rate of 2 gallons per surface acre. How many gallons of Diquat are needed?

a. Determine area with weeds because Diquat can be used for spot treatments:

¼ = 0.25; 0.25 x 8 acres = 2 acres

b. Determine gallons of Diquat needed:

2 gallons/surface acre x 2 acres = 4 gallons of Diquat



Medicated Feeds

Feeds containing an antibiotic or drug are sometimes needed to deliver medication orally to fish. For certain bacterial diseases that are systemic or found inside the body of fish, the only method of control is the oral administration of a recommended drug. In areas where commercial fish farming is practiced, medicated feeds with any approved drug of choice are available in 50 lb. bags. However, in many areas pre-formulated medicated feeds are unavailable. In some cases, only a small amount may be required, or in others a special formulation is desirable because high valued fish are feeding poorly. A complete disease diagnosis should be performed before any medicated feed is given to fish. These drug-supplemented feeds should not be fed fish unless recommended by a qualified fish health specialist.

The following provides information and examples on preparing medicated feeds. The use of Terramycin is most popular because of its availability from local veterinarians or pharmacists. These treatments are based on the body weight of fish. The standard units of treatment are grams of active drug per 100 pounds of fish per day.

Use the formula below to determine the amount of drug needed for a particular treatment.

$$\text{Weight of active drug} = \frac{W}{100} \times D \times T$$

Where: W = Total weight of fish treated in pounds
D = Dosage rate in grams of active drug per 100 lbs. of fish.
T = Treatment time in days

Example 1: How much active Terramycin is needed to treat 4,000 pounds of fish at the rate of 2.5 grams per 100 pounds of fish for 10 days?

$$\text{Weight of Terramycin (grams)} = \frac{4{,}000 \text{ lbs.}}{100 \text{ lbs.}} \times 2.5 \text{ grams/day} \times 10 \text{ days} = 1{,}000 \text{ grams or } 1 \text{ kilogram}$$

After the amount of drug needed is calculated, the next step is to determine how much feed is needed for the treatment time so the required amount of the drug can be mixed into the feed. Use the formula below to make this calculation:

Total Weight of Feed Needed for Treatment = W x F x T

Where: W = Total weight of fish treated in pounds
F = Feeding rate used in percent body weight
T = Days of treatment

Example 2. How much feed is needed for a 10-day treatment of the fish that will be fed 2% of their body weight daily?

Total weight of feed needed in pounds

4,000 lbs, x 0.02/day x 10 days = 800 lbs.

Fish in Examples 1 and 2 will be fed 800 pounds of feed that will contain 1,000 grams of active Terramycin for 10 days. Each 100 pounds of feed will contain 125 grams of active Terramycin.

$$\frac{1{,}000 \text{ grams active Terramycin}}{800 \text{ lbs. feed}} \times 100 \text{ lbs. feed} = 125 \text{ grams}$$

The amount of active drug required per 100 pounds of feed for different feeding and treatment rates can also be determined by referring to Table 16 in the Appendix.

To continue the problem, the amount of active drug per unit weight of material depends on the formulation of the commercial product. The amount of oxytetracycline hydrochloride (Terramycin) can vary from 10 to 25 grams in a 4-ounce packet.

To determine the amount of commercial product needed to supply the required quantjty of active drug, refer to the formula below:

$$\text{Pounds of Commercial Product Needed} = \frac{A}{D}$$

Where: D = Grams of active ingredient needed
A = Grams of active ingredient contained in 1 pound of commercial product

Exa,mple 3. How many pounds of a commercial product are required that contains 25 grams of active Terramycin per pound to supply 1,000 grams of active Terramycin?

Pounds of commercial product needed

$$\frac{\text{1,000 grams active needed}}{\text{25 grams/lb. commercial product}} = 40 \text{ lbs.}$$

The final calculation involves determining the amount of vegetable oil to dissolve the drug in and then mixing the solution into the dry feed. As a general rule, the amount of oil should equal about 3% of the weight of the feed. Make a small feed batch, and adjust oil content for your situation. Enough oil should be added to coat the feed thoroughly.

Example 4. For the treatment of the fish in Examples 1-3, 800 pounds of feed are needed. How much oil should be used to mix the drug into the feed?

$$\text{Given: } 3\% = \frac{3}{100} = 0.03$$

$$0.03 \times 800 \text{ lbs. feed} = 24 \text{ lbs. of oil}$$

To prepare the medicated feed, add the commercial product containing active Terramycin to the oil while stirring. Cover the feed with the oil-drug solution by mixing or spraying. To assure freshness, prepare a new medicated feed batch each day. Allow the coated feed to air-dry for 1 day before use. Adding some cod-liver oil to the vegetable oil sometimes improves feed palatability.

Terramycin can be purchased as a pre-mix often referred to as TM-50. This means that the product contains 50 grams of active Terramycin per pound. To determine how much pre-mix to purchase, use the formula below:

$$\frac{\text{50 grams active drug}}{\text{1 pound}} \quad \frac{\text{Grams active drug needed}}{\text{Amount of pre-mix needed}}$$

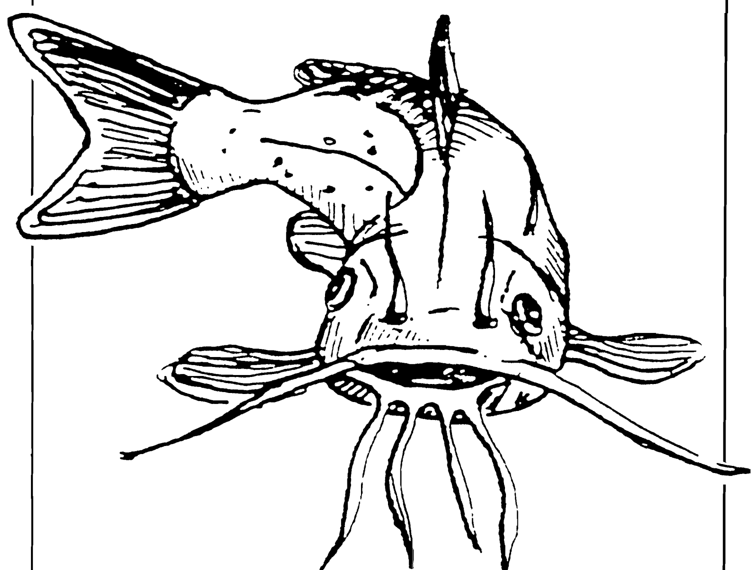
Example 5. In Examples 1-4, 1,000 grams of active Terramycin are required. How many pounds of TM-50 pre-mix are needed to supply 1,000 grams of active drug?

$$\frac{\text{50 grams active drug}}{\text{1 lb.}} \quad \frac{\text{1,000 grams active drug needed}}{\text{Pounds of TM-50 pre-mix}}$$

Pounds of TM-50 pre-mix =

$$\frac{\text{1,000 grams}}{\text{50 grams}} \times 1 \text{ lb.} = 20 \text{ lbs.}$$

When adding Terramycin to feed as an oil coating, it is desirable to use a source of Terramycin that is as pure as possible to minimize mixing and coating problems with carrier material.



Fertilizer Problems

Both organic and inorganic fertilizer materials are used in aquaculture. Inorganic fertilizers are available in both granular and liquid formulations.

Fertilizers are used to stimulate the natural production of aquatic organisms in ponds and establish blooms of microscopic algae called phytoplankton. The color of the bloom can limit sunlight penetration into deeper water to control the growth of nuisance rooted aquatic plants. Fertilizers should be applied in the morning on sunny days. The results are not always desirable, and overfertilization can cause water quality problems. Phosphorus is usually the plant nutrient that limits the development of phytoplankton, especially in older ponds.

The grade of an inorganic fertilizer is expressed as three numbers. The first number represents the percentage of nitrogen (N) in the fertilizer material, the second number represents the percentage of phosphorus (P_2O_5), and the third nurnber represents the percentage of potassium (K_2O). A complete fertilizer contains all three primary nutrien"ts. Refer to Table 17 in the Appendix for the grades of common fertilizers.

Example 1. A new pond is 3 acres in area, and the owner wants to fertilize it with an equivalent of 8 pounds of phosphorus and 8 pounds of nitrogen per acre. Triple superphosphate containing 46% phosphorus (P_2O_5) and ammonium nitrate containing 34% nitrogen (N) are available. How many pounds of each are required for one fertilizer treatment?

a. To determine the amount of superphosphate needed do the following: Triple superphosphate is expressed as 0-46-0 and ammonium nitrate is 34-0-0.

Pounds of fertilizer required per acre =

$$\frac{\text{Pounds fertilizer needed per acre}}{\text{\% Phosphorus in fertilizer expressed as a decimal}}$$

Pounds of Triple Superphosphate per acre required =

$$\frac{8 \text{ lbs./acre}}{0.46} = 17.4 \text{ lbs./acre}$$

b. The total amount of ammonium nitrate required to fertilize the 3-acre pond at the rate of 8 pounds of nitrogen per acre is calculated using the same procedure.

Pounds of ammonium nitrate per acre required =

$$\frac{8 \text{ lbs./acre}}{0.34} = 23.5 \text{ lbs./acre}$$

c. The total amount of triple superphosphate required is: 17.4 lbs./acre x 3 acres = 52.2 lbs.

d. The total amount of ammonium nitrate needed is: 23.5 lbs./acre x 3-acres = 70.5 pounds

Example 2. What is the cost per fertilizer application if triple superphosphate costs $6 per 50 lb. bag and ammonium nitrate costs $4.75 per 50 lb. bag?

Fertilizer	Amount	x	Per Unit cost	Cost ($)
Triple Superphosphate	52.2 lbs.	x	$6 per 50 lbs.	$ 6.24
Ammonium Nitrate	70.5 lbs.	x	$4.75 per 50 lbs.	$ 6.70
Total Cost				$12.94

a. An easy method to calculate the cost of the fertilizer application is to determine the number of units contained in the anlount that you will apply, then multiply the results by the cost per unit. Below is a step-by-step explanation. The total amount of triple superphosphate to be applied is 52.2 lbs. This fertilizer can be purchased in 50 lb. bags that cost about $6 each. The convenient unit in this case is 50 lbs.

To determine the number of units in the 52.2 lbs. of fertilizer needed, simply divide this amount by 50 lbs:

$$\frac{52.2 \text{ lbs.}}{50 \text{ lbs.}} = 1.04 \text{ units}$$

For the ammonium nitrate, the results are:

$$\frac{70.5 \text{ lbs.}}{50 \text{ lbs.}} = 1.41 \text{ units}$$

b. The last step is to multiply the number of units needed by the cost per unit:

1.04 units of triple superphosphate x $6 per unit = $6.24

1.41 units of ammonium nitrate x $4.75 per unit = $6.70

Example 3. A fingerling producer wants to get a fast bloom in a 6-acre nursery pond. He has liquid fertilizer that has a formula of 10-34-0. One gallon weighs about 11 pounds. How many quarts are required per application if the desired rate is 5 lbs./acre?

a. Convert the weight of the fertilizer to a volume unit that is easier to measure because the product is a liquid:

1 gallon = 4 quarts = 8 pints

$$\frac{5 \text{ lbs./acre}}{11 \text{ lbs.}} \times 4 \text{ quarts} = 1.8 \text{ quarts/acre}$$

b. 1.8 quarts/acre x 6 acres = 10.8 quarts or 2.7 gallons

Consta,nt-Flow Treatments

There are situations when treatment chemicals need to be added to aquaculture production or holding facilities that have continuous water flow during the time of treatment. In some cases, it is best to stop the water flow and use aeration as needed during the treatment. The following formulas and exa.mples. can be used to make necessary calculations when a constant-flow treatment is required. Liquid chemicals work best for constant-flow treatments but other chemicals can be dissolved before delivery begins. The tank or trough should be pre-treated before beginning chemical delivery from the siphon. A variety of containers can be used with an adjustable clamp on the siphon hose to control the delivery rate.

The formula below can be used to determine the amount of chemical needed:

$$\underset{\text{(gpm)}}{\text{Flow rate}} \times \underset{\text{(min.)}}{\text{Treatment time}} \times \text{ppm desired} \times \text{C F} \times \frac{100}{\%\text{AI}} = \text{Weight of chemical needed}$$

Example 1. A trough has a continuous flow of 5 gpm and needs a 60-minute constant-flow treatment of potassium permanganate at a concentration of 10 ppm. How many grams of potassium permanganate must be dispensed to maintain the desired treatment concentration?

$$5 \text{ gpm} \times 60 \text{ min.} \times 10 \text{ ppm} \times 0.0038 \text{ grams} \times \frac{100}{100} = 11.4 \text{ grams}$$

Four factors must be known before any treatment can start using a constant-flow device.

1. Total flow of water through tank during period of treatment. This is simply done by measuring the volume of water delivered in one minute and multiplying this value by the number of minutes in the treatment.

Example 2. A tank receives a flow of 4 gpm. A constant-flow treatment will last 60 minutes. How many gallons of water will flow through the tank?

4 gpm x 60 min. = 240 gallons

2. Total volume of solution which the siphon device will deliver during the period of treatment. Measure the volume of solution delivered in 5 minutes, and nlultiply this value by ⅕ the number of minutes in the treatment.

Example 3. A siphon device delivers 200 ml in 5 minutes. How many gallons will the siphon device deliver during a 60-minute treatment?

$$200 \text{ ml} \times \frac{60 \text{ minutes}}{5 \text{ minutes}} = 2{,}400 \text{ ml or } 2.4 \text{ liters}$$

3. The concentration of the chemical to be maintained during the treatment period in ppm. This value is known.

4. The amount of the chemical delivered from the siphon. This value cannot be calculated until values are obta.ined for factors 1 through 3.

Example 4. The water flow in a tank is 10 gpm, and a siphon device will deliver 100 ml of a chemical solution in 5 minutes. The desired treatment is using formalin at the rate of 167 ppm for 1 hour. How much formalin needs to be added to the siphon container?

a. Total volume of water to treat:

10 gallons/min. x 60 min. = 600 gallons

b. Volume of solution that siphon will deliver during treatment:

$$100 \text{ ml} \times \frac{60 \text{ min.}}{5 \text{ min.}} = 1{,}200 \text{ ml or } 1.2 \text{ liters}$$

c. The treatment concentration is 167 ppm or 1:6000.

d. How much formalin needs to be added to the siphon container?
Use the basic treatment formula:

$$V \times C.F. \times \text{ppm desired} \times \frac{100}{\%A.I.} = \text{grams of formalin}$$

$$600 \text{ gallons} \times 0.0038 \text{ grams} \times 167 \text{ ppm} \times \frac{100}{100} = 381 \text{ grams}$$

The specific gravity of formalin is 1.08, so to convert grams to milliliters:

$$\frac{381 \text{ grams}}{1.08 \text{ grams/nll}} = 353 \text{ ml}$$

The siphon device will contain 353 ml of formalin and 847 ml of water for a total of 1,200 ml.

Example 5. A 1,000-galion holding tank contains chlorinated water that contain 2 ppm chlorine and enters at 5 gpm. A siphon container holds 5 gallons of solution. How much sodium thiosulfate is needed to neutralize the chlorine, and what should the flow rate be from the siphon to provide continuous treatment for 24 hours? Given: 7.4 ppm sodium thiosulfate needed to neutralize each 1 ppm chlorine.

a. The amount of sodium thios41fate in grams needed each minute to neutralize the chlorine entering is:

Volume gpm x 0.0038 grams x chlorine concentration in ppm x 7.4 = grams sodium thiosulfate needed per minute

5 gpm x 0.0038 grams x 2 ppm x 7.4 = 0.28 grams

b. The amount of sodium thiosulfate neeaed for a 24-hour continuous flow treatment is:

0.28 grams/min. x 60 min./hr. x 24 hr./day = 403 grams/day

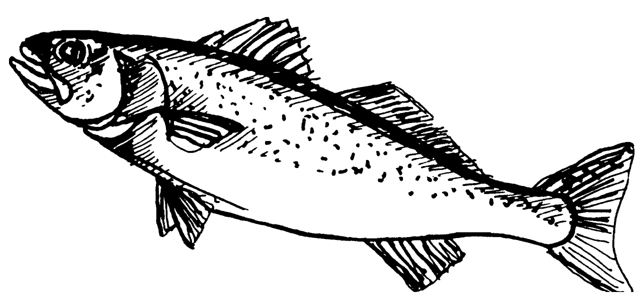
This means that 403 grams of sodium thiosulfate must be added to the 5-gallon siphon container every 24 hours with 5 gallons of water.

c. The flow rate of the continuous drip system in milliters of sodium thiosulfate solution per minute needed to neutralize all the chlorine in the 1,000-galion holding tank during 24 hours is calculated as follows:

$$\frac{\text{Volume of solution in milliters in siphon container}}{\text{Time in minutes}} = \text{Flow rate in mllmin. needed to deliver the required amount of chemical in 24 hrs.}$$

$$\frac{5 \text{ gal.} \times 3{,}785 \text{ ml/gal.}}{24 \text{ hrs.} \times 60 \text{ min./hr.}} = \text{Flow rate needed in m}^{1/}\text{min.}$$

$$\frac{18{,}927 \text{ ml}}{1{,}440 \text{ min.}}$$ 13.1 ml/min. flow rate needed to deliver 403 grams of sodium thiosulfate in 24 hours



Estimating Treatment Costs

It is important to know how to determine the costs of chemical treatments. These costs are used in preparing operating or production budgets, deciding whether a treatment is worth the cost and in managing finances.

Example 1. How much does it cost to treat a pond that contains 40 acre-feet with 6 ppm of potassium permanganate? Assume that a 110-pound drum costs $145.

a. Use the basic formula to determine how much potassium permanganate is required:

$$V \times C.F. \times \text{ppm desired} \times \frac{100}{\%A.I.} = \text{Amount chemical needed}$$

$$40 \text{ acre-feet} \times 2.7 \text{ lbs.} \times 6 \text{ ppm} \times \frac{100}{100} = 648 \text{ lbs.}$$

b. To determine the treatment cost:

Cost per unit x Number of units required = Cost of treatment

$$\$145/\text{unit} \times \frac{648 \text{ lbs.}}{110 \text{ lbs./unit}}$$

$$\$145/\text{unit} \times 5.89 \text{ units} = \$854$$

c. The cost can also be determined as follows if it is easier for you:

Cost/lb. x Total lbs. needed = Treatment cost

$$\frac{\$145}{110 \text{ lbs.}} \times 648 \text{ lbs.} = \$1.32/\text{lb.} \times 648 \text{ lbs.} = \$855$$

Example 2. A 7-acre pond with an average water depth of 5 feet requires a treatment of copper sulfate at the rate of 1.7 ppm. What is the cost of this treatment if a 50-pound bag of copper sulfate costs $25?

a. Determine the volume (V) of water to treat:

7 acres x 5 feet = 35 acre-feet of water

b. Use the basic treatment formula to determine how many pounds of copper sulfate are required:

$$\text{Amount copper sulfate required} = V \times C.F. \times \text{ppm desired} \times \frac{100}{\%AI} = 35 \text{ acre-feet} \times 2.7 \text{ lbs.} \times 1.7 \text{ ppm} \times \frac{100}{100} = 161 \text{ lbs. rounded off}$$

c. The treatment cost can be calculated as follows:

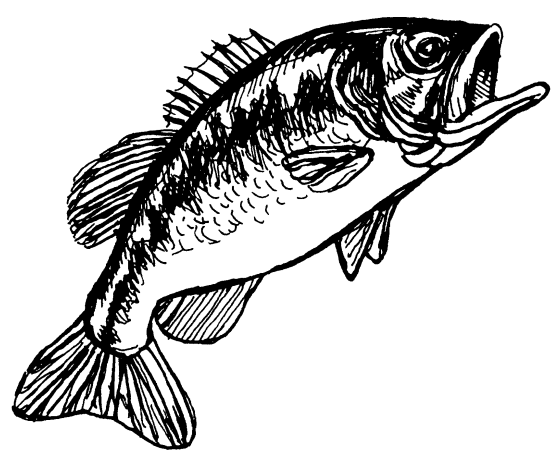
Cost per unit x Number of units required = Cost of treatment

$$\$25/\text{unit} \times \frac{161 \text{ lbs.}}{50 \text{ lbs./unit}} = \$80.50$$

d. The other method determines the cost per pound:

Cost/lb. x Total lbs. needed = Cost of treatment

$$\frac{\$25}{50 \text{ lbs.}} \times 161 \text{ lbs.} = \$0.50/\text{lb.} \times 161 \text{ lbs.} = \$80.50$$



Stock Solutions and Dilutions

Often, in hatchery operations, stock solutions of various chemicals are prepared. When these chemicals are used, the stock solution is diluted to obtain the desired concentration of the chemical.

The following general dilution formula makes calculations of dilution problems easy.

General dilution formula:

$$\frac{\text{Desired Concentration} \times \text{Desired Volume}}{\text{Concentration of Stock Solution}}$$

Volume of stock solution
to be diluted to desired volume

Example 1. Chlorox household bleach contains 5.25% available chlorine as sodium hypochlorite. A solution containing 200 ppm chlorine is desired for use as a disinfectant to clean hatchery troughs. One gallon of the disinfectant is desired. How much water is required to dilute the Chlorox?

a. The stock solution is the Chlorox that has a concentration of 5.25% chlorine.

b. The desired concentration of the disinfectant solution is 200 ppm = 200/1,000,000 = 0.02%.

c. The desired volume is 1 gallon or 3,785 milliliters (ml).

Using the general dilution formula:

$$\frac{\text{Desired Concentration} \times \text{Desired Volume}}{\text{Concentration of Stock Solution}}$$

Volume of stock solution
to be diluted to desired volume

$$\frac{0.02\% \times 3{,}785 \text{ ml}}{5.25\%} = 14.4 \text{ nll}$$

To obtain the 200 ppm chlorine disinfectant solution, simply measure about 15 ml of Chlorox and add it to 3,770 ml of water.

3,770 ml of water + 15 ml of Chlorox = 3,785 ml or 1 gallon

Hormone Injections for Induced Spawning

The hatchery production of some species of fish requires the administration of hormones to induce the ovulation of eggs in females and increase the volume and quality of milt (sperm) production in males. Induced spawning methods are also required to hybridize some species of fish where eggs are fertilized artificially.

The two most common ovulating materials used for induced spawning of fish are Human Chorionic Gonadotropin (HCG) and dried carp pituitary gland. These materials can be used singly or in combination, depending on the species being spawned and availability of material.

The following examples illustrate calculations to determine how much material to use and how to make dilutions to avoid injecting too much volume into the fish. Injections are given either intramuscular (1M) or intraperitoneal (IP).

Given: HCG is available as 10,000 International Units (ioU.) plus 10 milliliters of diluent. Dried carp pituitary is available as a ground powder and is sold by the gram.

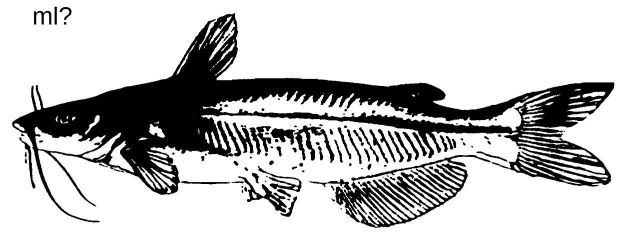
Exa.mple 1. Two females and one male fish require a three-injection series for induced spawning purposes. The following schedule is required:

First injection: Females with HCG @ 150 LU.Ilb. body weight

Second injection: Females with HCG @ 750 LU./lb. body weight

Resolving injection: Fenlales with dried carp pituitary @ 1.5 mg/lb. body weight
Males with dried carp pituitary @ 1 mg/lb. body weight

One female weighs 8 Ibs. and the other weighs 10 Ibs. The single male weighs 12 Ibs. How much HCG and carp pituitary are required for the injection series and each injection per fish? Also, what is the proper dilution if the total volume of each material injected into each fish cannot exceed 1 ml?



a. First determine the amount of each material required for each injection for all fish. This is easily done by making a table as follows:

	Female #1	Female #2	Male #1	Total Material
Total weight (Ibs.)	8	10	12	
First Injection HCG @ 150 I.U.Ilb.				
Amount needed (I.U.)	1,200	1,500		2,700I.U.
Second Injection HCG @ 750 I.U.Ilb.				
Amount needed (IoU.)	6,000	7,500		13,500 ioU.
Total HCG needed (I.U.)				16,200 I.U.
Resolving (Final) Injection Carp pituitary @ 1.5 mg/lb. for females, Carp pituitary @ 1.0 mg/lb. for males Amount needed (mg.)	12	15	12	39 mg.

b. Determine how many vials or units of HCG need to be purchased based on requirements:

Given: One vial or unit of HCG contains 10,000 LU.

$$\text{Number vials} = \frac{\text{Total HCG needed as LU.}}{\text{Number I.U./vial}}$$

$$\text{Number vials} = \frac{\text{16,200 I.U.}}{\text{10,000I.U./vial}}$$

= 1.62 or 2 (rounded number)

c. The total amount of carp pituitary required as milligrams (mg) is 39.

d. Next, determine the dilution rate for the 10,000 I.U. in the 10 ml of diluent not to exceed 1 ml of material for any injection:

1. For the first injection, 2,700 I.U. are required and the largest dose is ·1,500 I.U. Mix the 10,000 I.U. with 5 ml of the diluent. This dilution is equal to:

$$\frac{\text{10,000 LU.}}{\text{5 ml.}} = \text{2,000I.U./ml}$$

For female #1, the amount of the HCG diluent mixture to inject is equal to:

$$\frac{\text{1,200 I.U. needed}}{\text{2,000 LU./ml}} = \text{0.6ml}$$

To double-check the results:

2,000 I.U./ml x 0.6 ml = 1,200 I.U.

For female #2, the amount of the HCG diluent mixture to inject is equal to:

$$\frac{\text{1,500 I.U. needed}}{\text{2,000 I.U./ml}} = \text{0.75 ml}$$

To double-check:

2,000 LU./ml x 0.75 ml = 1,500 I.U.

2. Forthe second injection with HCG, the largest dose is 7,500 LU. This time mix 10,000 LU. with only 1 ml of the diluent.
This dilution is equal to:

$$\frac{\text{10,000 I.U.}}{\text{1 ml}} = \text{10,000 I.U./ml}$$

For female #1, the amount of the HCG diluent mixture to inject is equal to:

$$\frac{6{,}000 \text{ IU. needed}}{10{,}000 \text{ LU./ml}} = 0.6 \text{ ml}$$

To double-check the results:

10,000 LU./ml x 0.6 ml = 6,000 ioU.

For female #2, the am.ount of HCG diluent mixture to inject is equal to:

$$\frac{7{,}500 \text{ IU. needed}}{10{,}000 \text{ LU./ml}} = 0.75 \text{ ml}$$

To double-check:

10,000 LU./ml x 0.75 ml = 7,500 ioU.

For the resolving injection, the amount of carp pituitary in mg required for each fish should be weighed accurately and mixed in 1 ml of diluent or distilled water.

Conversion Examples

It is often necessary to convert units used in aquaculture from one unit to another. Sometimes, publications report production results in kilograms per hectare (kg/ha) rather than pounds per acre *(lbs.1* acre). The following are examples of some conversions that a.re common in aquaculture calculations. Tables 13 to 15 can be used to make conversions easier.

Example 1. To convert 3,600 kg/ha to lbs./acre, use the conversion factor of 0.891.
3,700 kg/ha x 0.891 = 3,297 lbs./acre

Example 2. To convert 4,000 lbs./acre to kg/ha, use the conversion factor 1.125.
4,000 lbs.lacre x 1.125 = 4,500 kg/ha

Example 3. To convert 250 ppm to a dilution ratio concentration:

$$\frac{1{,}000{,}000}{250} = 1:4000$$

Example 4. To convert 1:8000 dilution ratio concentration to ppm:

$$\frac{8{,}000}{1{,}000{,}000} = .008 = \frac{1}{.008} = 125 \text{ ppm}$$

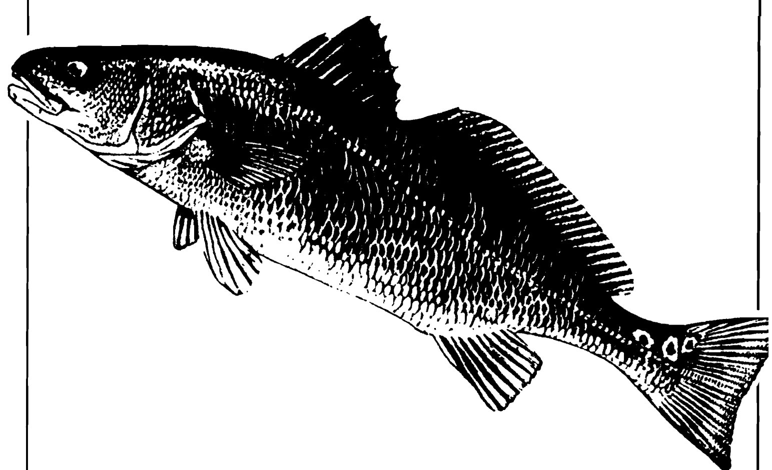
Example 5. To convert 5,000 ppm to percent solution:

$$\frac{5{,}000}{1{,}000{,}000} \times 100 = 0.5\%$$

Example 6. To convert 500 ppm to parts per thousand (ppt):

$$\frac{500 \text{ ppm}}{1{,}000} = 0.5 \text{ ppt}$$

Example 7. To convert 15.7 ppt to ppm:
15.7 ppt x 1,000 = 15,700 ppm



Seine Length and Depth

Seines can be made of any length or depth specified. There are choices of mesh sizes, mesh styles and optional features like net coating, bags and size of twine. When ordering a seine, it is important to match the dimensions of the seine with your requirements. Seines should bag as they are pulled. Refer to Table 18 in the Appendix for the net mesh sizes for grading catfish.

As a general rule, the length of the seine should be at least 3 feet long for every 2 feet of width across which the pond will be seined. For rectangular ponds, the narrowest width of the pond is seined. When determining the width of the pond to be seined, make sure to measure the longest width, and use this value when determining the proper seine length. The seine depth should also be 3 feet deep for every 2 feet of water depth to be seined. Again, make sure that the depth of the seine is sufficient to use properly in the deepest water that will be seined. Purchase a seine for proper use in the largest pond. Then it can also be used in any other pond.

Example 1. A rectangular pond is 1,000 feet long and 500 feet wide. The deepest water that will be seined is 6 feet. What is the recommended length and depth for a seine to be used in this pond?

a. First determine the proper seine length that is 3 feet for every 2 feet of pond width. Take the longest pond width that is 500 feet and determine the number of 2-foot sections.

$$\frac{500 \text{ feet}}{2 \text{ feet/section}} = 250 \text{ sections each 2 feet long}$$

$$250 \text{ sections} \times 3 \text{ feet/2 feet section} = 750\text{-foot-long seine}$$

b. Determine the depth of the seine by using the same procedure. The maximum depth of water to seine is 6 feet. The depth of seine should be 3 feet for every 2 feet of water depth.

$$\frac{6 \text{ feet}}{2 \text{ feet/section}} = 3 \text{ sections each 2 feet long}$$

$$3 \text{ sections} \times 3 \text{ feet/2 foot section} = 9 \text{ feet deep}$$

c. A shortcut method is: multiply the width of pond and depth of water by 1.5 because $3/2 = 1.5$.

$$500 \text{ feet wide} \times 1.5 = 750 \text{ feet}$$

$$6 \text{ feet deep} \times 1.5 = 9 \text{ feet}$$

Fill Dirt for Pond Levees

The amount of dirt required to build or fill a pond levee or dam can be estimated by knowing the cross-sectional area of the levee and length of levee. For levees that are of uniform height, it is not necessary to divide the levee into small sections, then add the earth fill for each section. For long levees with varying heights, it is necessary to divide the dam into sections each 25 to 50 feet long and determine the amount of dirt needed for each section. Refer to Table 19 in the Appendix for estimates of approximate dirt fill needed for various size levees on flatland.

The general formula to determine the cross-sectional area of a levee is:

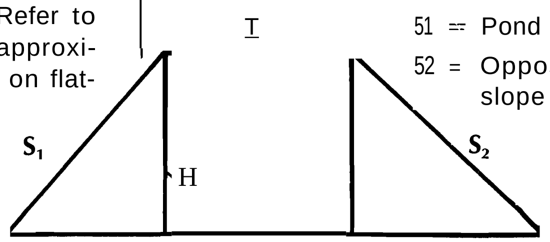
$$\text{Cross-sectional Area (Feet}^2) = H\left[T + \left(\frac{S_1 + S_2}{2}\right)H\right]$$

Where: T = Top width of levee in feet

H = Height of levee in feet

51 = Pond side slope of levee

52 = Opposite outside slope of levee



Notes: If both slopes of the levee are the same, then use the value of one slope (5) to replace $\frac{51 + 52}{2}$. If slopes are unequal, then use $\frac{51 + 52}{2}$

To estimate the cubic yards of dirt required to build a levee, use the formula below:

$$\frac{\text{Cross-sectional area of levee (ft.}^2) \times \text{Length of levee (ft.)}}{27} = \text{Cubic yards (yd}^3\text{) of dirt required}$$

By knowing the volume of dirt required, the cost of construction can be estimated if dirt work is charged by the cubic yard moved rather than by the hour that equipment is operated.

Cost of levee = Total yd.^{3} of dirt required x Cost/yd^3.

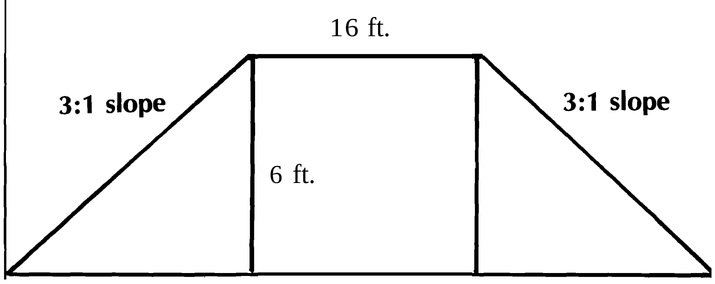
Example 1. Below are the dimensions for the cross-section of a levee that will be built. The total length of the levee will be 1,500 feet. Approximately how many cubic yards of dirt are needed to build this levee, and what is the cost if dirt is moved at $.60/cubic yard? Note: The amount of dirt moved is loose dirt and not compacted dirt. Determine the amount of dirt needed based on the designed height of the levee before settling. A levee may settle 5 to 10% or more of its height when constructed, depending on the soil type and how well it is compacted during construction.

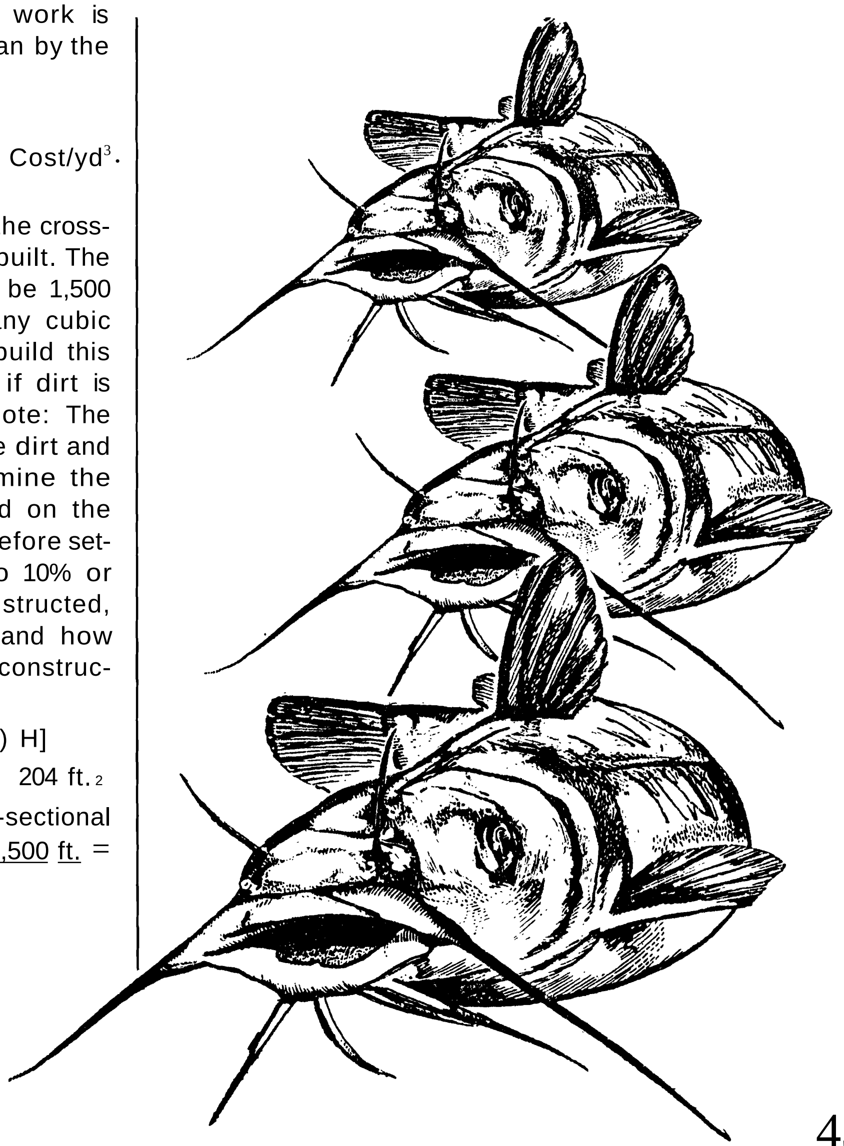
a. Cross-sectional area (ft.^{2}) = HIT + (5) H]
$= 6[16 + (3)6] = 6(16+18) = 6(34) = 204$ ft.^{2}

b. Cubic yards of dirt needed = $\frac{\text{Cross-sectional area x levee length}}{27} = \frac{204 \text{ ft.}^2 \times 1{,}500 \text{ ft.}}{27} =$

$\frac{306{,}000 \text{ ft.}^3}{27} = 11{,}333$ yd.^{3}

c. Construction cost is: 11,333 yd.^{3} x $.60/yd.^{3} = $6,800





Appendix

Table 1. Estimated pond filling time in days at different pumping rates.[1]

Pond Size (acres)	Pumping Rate (gpm) 200	500	1,000	1,500	2,000	3,000
1	4.5	1.8	0.9	0.6	0.5	0.3
2	9	3.6	1.8	1.2	0.9	0.6
5	23	9	4.5	3	2.3	1.5
10	45	18	9	6	4.5	3
20	90	36	18	12	9	6

1Assume average water depth of 4 feet. Does not include losses or gains from rainfall, seepage or evaporation.

Table 2. Estimated average discharge rates for short drainpipes in fish ponds of various sizes with low head pressure.[1]

Diameter of Pipe (Inches)	Approx. Discharge (gpm)
4	125
6	350
8	600
10	1,000
12	1,600
14	2,400

1To estimate the drain time in days for a pond using various sizes of drainpipe, use the formula below:

$$\frac{\text{Acre-feet water} \times 325{,}851}{\text{Discharge gpm} \times 1440} = \text{Drain time in days}$$

Table 3. Water flow rates equivalent to acre-feet of water per day[1]

Flow Rate (gpm)	Acre-Feet[2] Per Day
50	0.22
100	0.44
200	0.88
300	1.33
400	1.77
500	2.21
750	3.31
1,000	4.42
1,500	6.63
2,000	8.84
2,500	11.05
3,000	13.26
4,000	17.68
5,000	22.09

[1]Values are not corrected for precipitation, evaporation and seepage.

[2]To determine filling time for a pond, divide the estimated total acre-feet of water in pond by any continuous pumping rate value in acre-feet per day.

Example: $\frac{\text{60 acre-feet water}}{\text{8.84 acre-feet}} \times \text{1 day} = $ 6.8 days to fill your pond with a 2,000 gpm well.

Table 4. Approximate discharge rates from deep wells of various sizes.

Well Size (Inches)	Maximum Discharge (gpm)
4	90
6	400
8	600
10	1,000
12	2,000

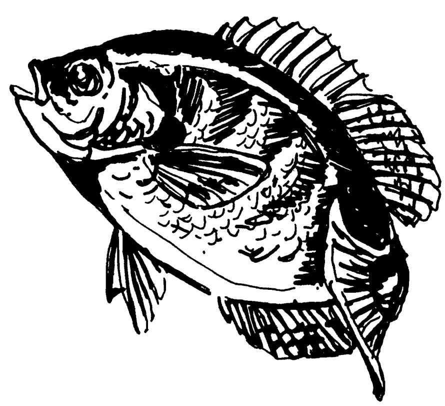


Table 5. Guide to recommended well casing sizes for various pumping rates.

Anticipated Well Yield (gpm)	Nominal Size of Pump Bowls (inches)	Smallest Size Well Casing (inches)*	Optimum Size of Well Casing (inches)
150 to 400	6	81D	10ID
350 to 650	8	10ID	121D
600 to 900	10	121D	14 aD
850 to 1,300	12	14 aD	16 aD
1,200 to 1,800	14	16 aD	20 aD
1,600 to 3,000	16	20 aD	24 aD

* ID refers to inside diameter and OD refers to outside diameter

The above values are not limiting because variable factors are water level, yield of water-bearing formation and pressure developed in well.

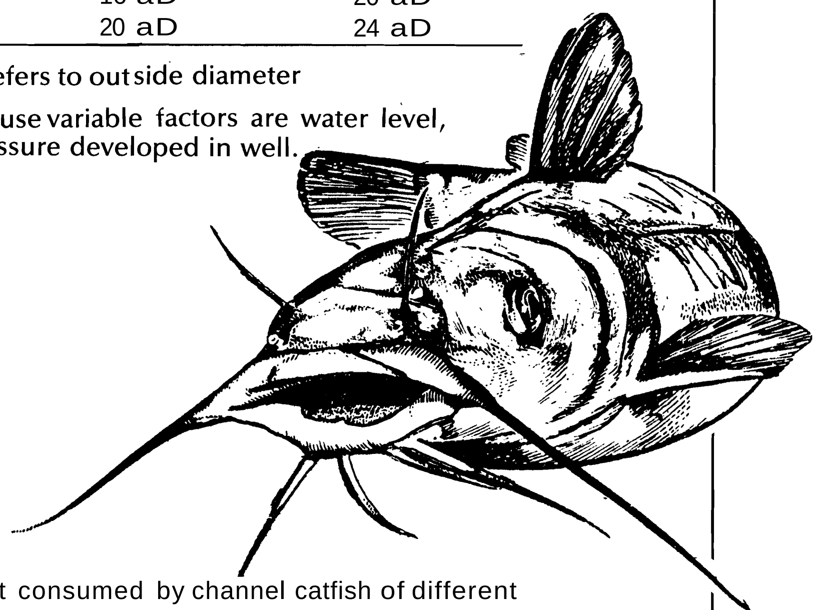


Table 6. Estimated percent body weight consumed by channel catfish of different sizes at water temperatures above 70°F.

Fish Size		
Average Weight (pounds)	Pounds per 1,000 Fish	Estimated Percent Body Weight Consumed Daily
0.02	20	4.0
0.06	60	3.0
0.25	250	2.7
0.50	500	2.5
0.70	750	2.2
1.00	1,000	1.6
1.50	1,500	1.3

Table 7. Guide to winter feeding of catfish of various sizes.

For Catfish ½ Pound and Larger:

Water Temperature °F	°C	% of Total Fish Weight to Feed/Feeding	Feeding Frequency
45-50	7-10	0.5	Once/week
51-55	10-13	1.0	Twice/week
56-60	13-16	1.0	Every other day
61-65	16-18	1.5	Every other day
66-70	19-21	2.0	Every other day

For Fingerling Catfish Smaller Than ½ Pound:

Water Temperature °F	°C	% of Total Fish Weight to Feed/Feeding	Feeding Frequency
45-50	7-10	0.5	3 days/week
51-55	10-13	1.0	Every other day
56-60	13-16	1.0	6 days/week
61-65	16-18	2.0	6 days/week
66-70	19-21	2.5	6 days/week

Determine water temperature at 3-foot depth during mid-afternoon.

Table 8. Length-weight relationship for channel catfish fingerlings and food fish.

Total Length (inches)	Average Weight per Thousand Fish (pounds)	Number of Fish per Pound	Average Weight per Fish (pounds)
1	1.3	767.7	.0013
2	3.5	285.7	.0035
3	10.0	100.0	.0100
4	20.0	50.0	.0200
5	32.0	31.1	.0321
6	60.0	17.0	.0588
7	93.0	10.8	.0926
8	112.0	9.0	.1111
9	180.0	5.5	.1818
10	328.0	3.1	.3280
11	395.0	2.5	.3950
12	509.0	1.9	.5090
13	656.0	1.5	.6560
14	850.0	1.1	.8500
15	1090.0	0.92	1.0900
16	1290.0	0.82	1.2900
17	1432.0	0.69	1.4320
18	1750.0	0.57	1.7500
19	2200.0	0.45	2.2000
20	2890.0	0.35	2.8900
21	3290.0	0.30	3.2900
22	3470.0	0.29	3.4700
23	3600.0	0.28	3.6000

Table 9. Record form used to calculate pounds of harvestable catfish in a pond with mixed sizes.

Total Fish Length (inches)	Tally Marks (1 per fish)	Number of Fish per Inch Group		Average Weight per Fish	Total Weight per Inch Group
1		___	x	.0013	___
2		___	x	.0035	___
3		___	x	.0100	___
4		___	x	.0200	___
5		___	x	.0321	___
6		___	x	.0588	___
7		___	x	.0926	___
8		___	x	.1111	___
9		___	x	.1818	___
10		___	x	.3280	___
11		___	x	.3950	___
12		___	x	.5090	___
13		___	x	.6560	___
14		___	x	.8500	___
15		___	x	1.0900	___
16		___	x	1.2900	___
17		___	x	1.4320	___
18		___	x	1.7500	___
19		___	x	2.2000	___
20		___	x	2.8900	___
21		___	x	3.2900	___
22		___	x	3.4700	___
23		___	x	3.6000	___
	Total Fish Sampled	___		Total Wt. =	___

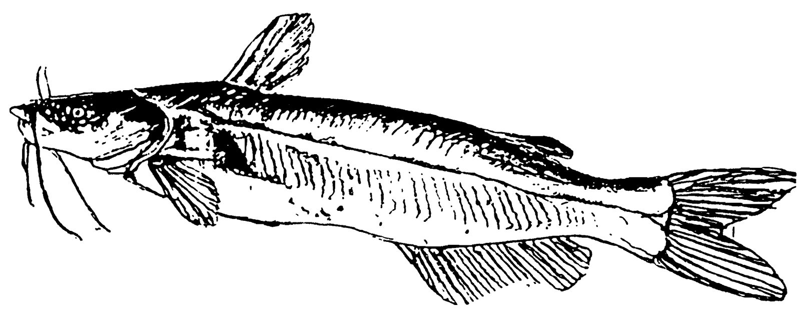


Table 10. Conversion Factors (C.F.) are the weight of a chemical that must be added to one unit volume of water to give one part per million (ppm).

2.72 pounds per acre-foot	1 ppm
1,233 grams per acre-foot	1 ppm
0.0283 grams per cubic foot	1 ppm
0.0000624 pounds per cubic foot	1 ppm
0.0038 grams per gallon	1 ppm
0.0584 grains per gallon	1 ppm
1 milligram per liter	1 ppm
0.001 gram per liter	1 ppm
8.34 pounds per million gallons of water	1 ppm
1 gram per cubic meter	1 ppm
1 milligram per kilogram	1 ppm
10 kilograms per hectare-meter	1 ppm

Table 11. Conversion for parts per million, proportion and percent.

Parts per million	Proportion	Percent
0.1	1:10,000,000	0.000010
0.25	1:4,000,000	0.000025
1.0	1:1,000,000	0.0001
2.0	1:500,000	0.0002
3.0	1:333,333	0.0003
4.0	1:250,000	0.0004
5.0	1:200,000	0.0005
8.4	1:119,047	0.00084
10.0	1:100,000	0.001
15.0	1:66,667	0.0015
20.0	1:50,000	0.002
25.0	1:40,000	0.0025
50.0	1:20,000	0.005
100.0	1:10,000	0.01
150.0	1:6,667	0.015
167.0	1:6,000	0.0167
200.0	1:5,000	0.02
250.0	1:4,000	0.025
500.0	1:2,000	0.05
1667.0	1:600	0.1667
5000.0	1:200	0.5
6667.0	1:150	0.667
30000.0	1:33	3.0

Table 12. Miscellaneous conversion factors for aquaculture use.

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	= 62.4 pounds
1 gallon of water	= 8.34 pounds
1 gallon of water	= 3,785 grams
1 liter of water	= 1,000 grams
1 fluid ounce	= 29.57 grams
1 fluid ounce	= 1.043 ounces
1 grain per gallon	= 17.1 milligrams/liter
1 milliliter of water	= 1 gram
1 cubic meter of water	= 1 metric ton
1 quart of water	= 946 gran1s
1 teaspoon	= 4.9 milliliters
1 tablespoon	= 14.8 milliliters
1 cup	= 8 fluid ounces
1 acre-foot/day of water	= 226.3 gallons/minute
1 acre-inch/day of water	= 18.9 gallons/minute
1 acre-inch/hour of water	= 452.6 gallons/minute
1 second foot of water	= 448.8 gallons/minute
1 cubic foot/second of water	= 448.8 gallons/n1inute
1 foot of water	= 0.43 pounds/square inch
1 foot of water	= 0.88 inch of mercury (HG)
1 horsepower	= 550 foot-pounds/second
1 horsepower	= 745.7 watts
1 kilowatt	= 1,000 watts
1 kilowatt	= 1.34 horsepower
1 hectare	= 10,000 square meters
1 hectare	= 2.47 acres
1 acre	= 4,048 square meters

Table 13. Conversions for units of weight.

FROM \ TO	gm	kg	gr	oz	lb
gm	1	0.001	15.43	0.0353	0.0022
kg	1000	1	1.54×10^{4}	35.27	2.205
gr	0.0648	6.48×10^{-5}	1	0.0023	1.43×10^{-4}
oz	28.35	0.0284	437.5	1	0.0625
lb	453.6	0.4536	7000	16	1

gm = gram; kg = kilogram; gr. = grain; oz. = ounce; lb. pound

Table 14. Conversions for units of length.

FROM	TO				
	cm	m	in.	ft.	yd.
cm	1	0.01	0.3937	0.0328	0.0109
m	100	1	39.37	3.281	1.0936
in.	2.540	0.0254	1	0.0833	0.0278
ft.	30.48	0.3048	12	1	0.3333
yd.	91.44	0.9144	36	3	1

cm = centimeter; m = meter; in. = inches; ft. = foot; yd. = yard

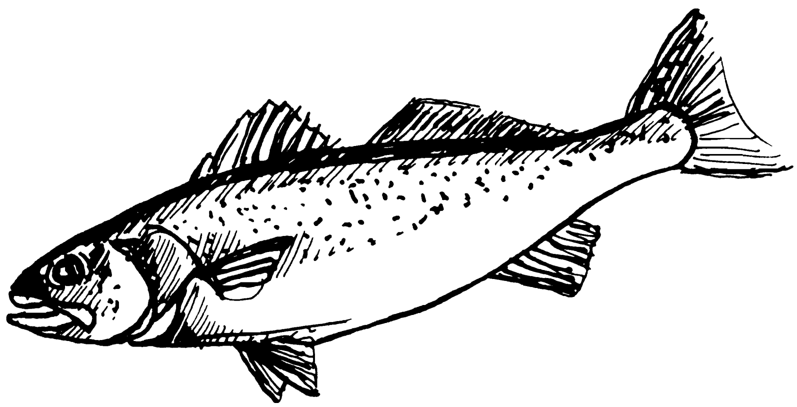


Table 15. Conversion for Units of Volume.

FROM	TO								
	cm^3	liter	m^3	$in.^3$	$ft.^3$	fl. oz.	fl. pt.	fl. qt.	gal.
cm^3	1	0.001	1×10^{-6}	0.0610	3.53×10^{-5}	0.0338	0.00211	0.00106	2.64×10^{-4}
liter	1000	1	0.001	60.98	0.0353	33.81	2.113	1.057	0.2642
m^3	1×10^{6}	1000	1	6.1×10^{4}	5.31	3.38×10^{4}	2113	1057	264.2
$in.^3$	16.39	0.0164	1.64×10^{-5}	1	5.79×10^{-4}	0.5541	0.0346	0.0173	0.0043
$ft.^3$	2.83×10^{4}	28.32	0.0283	1728	1	957.5	59.84	29.92	7.481
fl. oz.	29.57	0.0296	2.96×10^{-5}	1.805	0.00104	1	0.0625	0.0313	0.0078
fl. pt.	473.2	0.4732	4.73×10^{-4}	28.88	0.0167	16	1	0.5000	0.1250
fl. qt.	946.4	0.9463	9.46×10^{-4}	57.75	0.0334	32	2	1	0.2500
gal.	3785	3.785	0.0038	231.0	0.1337	128	8	4	1

cm^3 = cubic centimeter = milliliter = ml; m^3 = cubic meter; $in.^3$ = cubic inch; $ft.^3$ = cubic foot; fl. oz. = fluid ounce; fl. pt. = fluid pint; fl. qt. = fluid quart; gal. = gallon

Table 16. Grams of active drug needed per 100 pounds of feed at various feeding and treatment rates.

% Fed per Pound of Body Weight Daily	Grams of Active Drug Needed per 100 lbs. of Fish per day					
	2.0	2.5	3.0	4.0	4.5	10.0
1.0	200	250	300	400	450	1000
1.2	167	208	250	333	375	833
1.4	143	179	214	286	321	714
1.6	125	156	188	250	281	625
1.8	111	139	167	222	250	556
2.0	100	125	150	200	225	500
2.2	91	114	136	182	205	455
2.4	83	104	125	167	188	417
2.6	77	96	115	154	173	385
2.8	71	89	107	143	161	357
3.0	67	83	100	133	150	333
3.2	63	78	94	125	141	313
3.4	59	74	88	118	132	294
3.6	56	69	83	111	125	278
3.8	53	66	79	105	118	263
4.0	50	63	75	100	113	250
4.2	48	60	71	95	107	238
4.4	45	57	68	91	102	227
4.6	43	54	65	87	98	217
5.0	40	50	60	80	90	200
5.5	36	45	55	73	82	182
6.0	33	42	50	67	75	167

Table 17. Composition of some common inorganic fertilizers.

Fertilizer	Percentage[1]		
	N		
Ammonium nitrate	33-35		
Ammonium sulfate	20-21		
Calcium nitrate	15.5		
Ammonium phosphates	11-16	20-48	
Muriate of potash			50-62
Potassium nitrate	13		44
Potassium sulfate			50
Sodium nitrate	16		
Superphosphate (ordinary)		18-20	
Superphosphate (double or triple)		32-54	
Urea	45		

Refer to the information on the fertilizer bag or label to determine the grade for a specific fertilizer.

[1]N refers to nitrogen; P20S refers to phosphorus; and K20 refers to potassium.

Table 18. Net mesh sizes for grading catfish.

Square Mesh Size in Inches	Holds Fish Larger or Equal To
2	2 pounds
1¾	1V2 pounds
1⅝	1 pound
1⅜	34 pound
1	V2 pound (8-10 inches)
¾	0.1 pound (7-8 inches)
½	4-5 inches
⅜	3-4 inches
¼	1-2 inches

Note: Fish are more difficult to grade in cool water. More time is required for grading. Larger mesh sizes reduce the chance of harvesting fish of an undesirably small size.

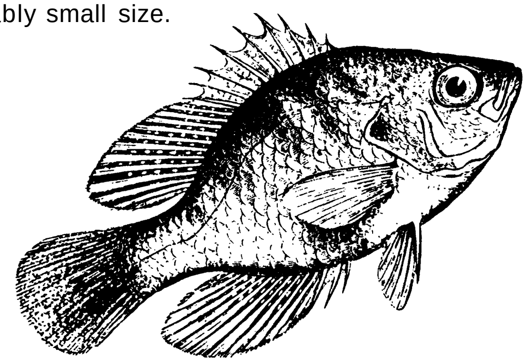


Table 19. Approximate volume of dirt to fill a one-foot length section of levee of various sizes on flatland.[1]

Levee Height (Feet)	Slopes Total 6:1[2]					Slopes Total 7:1[3]				
	Top Widths					Top Widths				
	12	14	16	18	20	12	14	16	18	20
5	5.00	5.37	5.74	6.11	6.48	5.46	5.83	6.20	6.57	6.94
5.2	5.32	5.70	6.09	6.47	6.86	5.82	6.20	6.59	6.97	7.36
5.4	5.64	6.04	6.44	6.84	7.24	6.18	6.58	6.98	7.38	7.78
5.6	5.97	6.39	6.80	7.22	7.63	6.55	6.97	7.38	7.80	8.21
5.8	6.32	6.75	7.17	7.60	8.03	6.94	7.37	7.80	8.23	8.66
6.0	6.67	7.11	7.56	8.00	8.44	7.33	7.78	8.22	8.67	9.11
6.2	7.03	7.49	7.95	8.40	8.86	7.74	8.20	8.66	9.12	9.58
6.4	7.40	7.87	8.34	8.82	9.29	8.15	8.63	9.10	9.58	10.05
6.6	7.77	8.26	8.75	9.24	9.73	8.58	9.07	9.56	10.05	10.54
6.8	8.16	8.66	9.17	9.67	10.17	9.02	9.52	10.02	10.53	11.03

[1]Values represent cubic yards of dirt per linear foot of the length of the levee.
[2]6:1 total slope equals a levee with inside and outside slopes each of 3:1.
[3]7:1 total slope equals a levee with a 3:1 slope on one side and a 4:1 slope on the other side.

Table,20. Centigrade and Fahrenheit temperature equivalents

°C	of	°C	of	°C	of
0	32.0	14	57.2	28	82.4
1	33.8	15	59.0	29	84.2
2	35.6	16	60.8	30	86.0
3	37.4	17	62.6	31	87.8
4	39.2	18	64.4	32	89.6
5	41.0	19	66.2	33	91.4
6	42.8	20	68.0	34	93.2
7	44.6	21	69.8	35	95.0
8	46.4	22	71.6	36	96.8
9	48.2	23	73.4	37	98.6
10	50.0	24	75.2	38	100.4
11	51.8	25	77.0	39	102.2
12	53.6	26	78.8	40	104.0
13	55.4	27	80.6		

Table 21. Solubility of oxygen in parts per million (ppm) in fresh water at various temperatures and at a pressure of 760 mm Hg (sea level).

Temperature		Oxygen Concentration (ppm)	Temperature		Oxygen Concentration (ppm)
of	°C		of	°C	
32	0	14.6	69.8	21	9.0
33.8	1	14.2	71.6	22	8.8
35.6	2	13.8	73.4	23	8.7
37.4	3	13.5	75.2	24	8.5
39.2	4	13.1	77	25	8.4
41	5	12.8	78.8	26	8.2
42.8	6	12.5	80.6	27	8.1
44.6	7	12.2	82.4	28	7.9
46.4	8	11.9	84.2	29	7.8
48.2	9	11.6	86	30	7.6
50	10	11.3	87.8	31	7.5
51.8	11	11.1	89.6	32	7.4
53.6	12	10.8	91.4	33	7.3
55.4	13	10.6	93.2	34	7.2
57.2	14	10.4	95.0	35	7.1
59	15	10.2	96.8	36	7.0
60.8	16	10.0	98.6	37	6.8
62.6	17	9.7	100.4	38	6.7
64.4	18	9.5	102.2	39	6.6
66.2	19	9.4	104.0	40	6.5
68	20	9.2			

Table 22. Altitude correction factor for the solubility of oxygen in fresh water.

Atmospheric Pressure (mm HG)	or Equivalent Altitude (Ft.)	Correction Factor
775	540	1.02
760	O	1.00
745	542	.98
730	1094	.96
714	1688	.94
699	2274	.92
684	2864	.90
669	3466	.88
654	4082	.86
638	4756	.84
623	5403	.82
608	6065	.80
593	6744	.78
578	7440	.76
562	8204	.74
547	8939	.72
532	9694	.70
517	10472	.68
502	11273	.66

Example: Solubility of oxygen at sea level (760 mm Hg) at 20°C is 9.2 ppm. The solubility of oxygen at an altitude of 1,688 feet in 20°C water is 9.2 ppm x 0.94 (Correction Factor) = 8.65 ppm

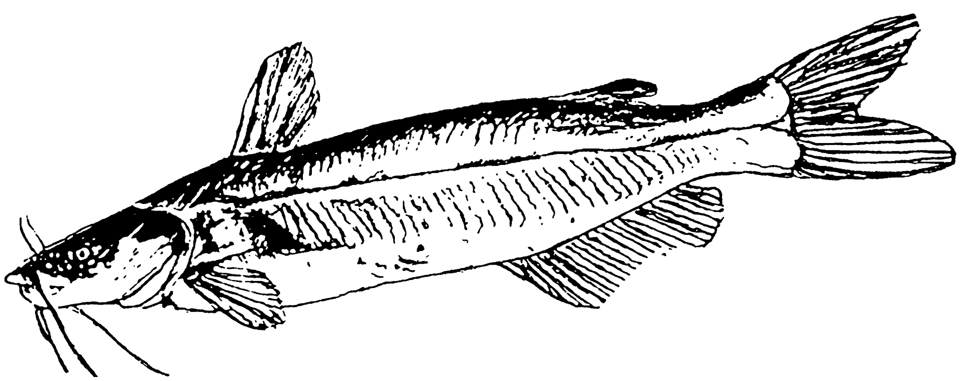
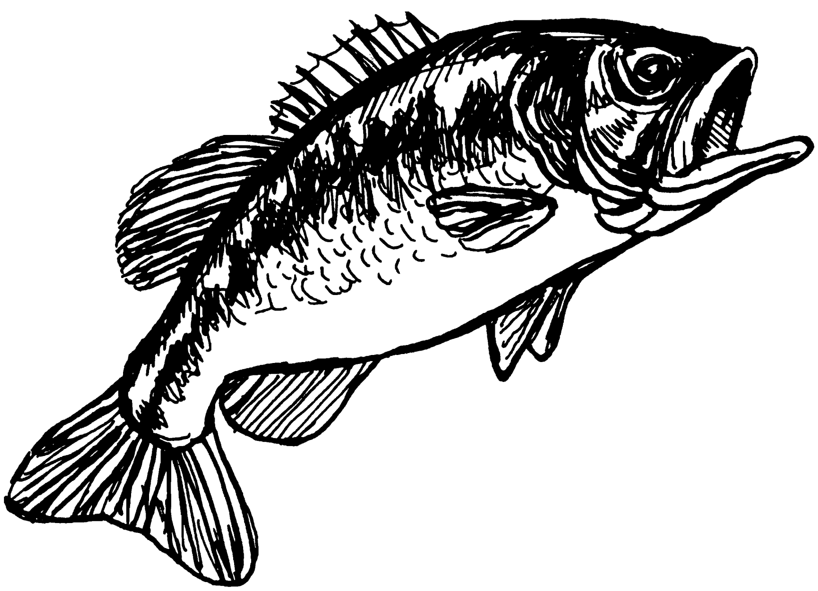


Table 23. Number of water samples required from ponds to estimate the averages of water quality variables with a 95% certainty that errors will not exceed the specified values.

Water Quality Variable	Number of Water Samp'les Per Determination
Dissolved Oxygen	
± 0.5 ppm	6
± 1.0 ppm	2
pH	
± 0.5 unit	1
± 1.0 unit	1
Temperature	
± 0.5°C	2
± 1.0°C	1
Total Hardness	
± 1.0 ppm	1
Secchi disk (underwater) visibility	
± 5 cm	7
± 10 cm	2



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Acknowledgments

The author wishes to thank the following for their review of the publication and useful comments: Dr. James Avault, jr., Louisiana Agricultural Experiment Station, Mr. William Hadden, Louisiana Cooperative Extension Service, and Dr. Ron Thune, Louisiana Agricultural Experiment Station and School of Veterinary ·Medicine.

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Pub. 8903 (500) 6/98 Rep.

Issued in furtherance of Cooperative Extension work, Acts of Congress of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. The Louisiana Cooperative Extension Service provides equal opportunities in programs and employment.