AERATION OF FARM PONDS

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AERATION is defined as the mixing of air and water through wind action or by forcing air through water. It is a process by which oxygen is dissolved in water. Adequate dissolved oxygen (DO) is necessary in water to sustain fish and other aquatic life and for fish to grow and to keep them from being susceptible to disease. In order to understand the importance of DO better we need to look at some of the principles concerning water and oxygen.

The chemical formula for water is H_2O. The H stands for two hydrogen ions and the O for one oxygen ion. This oxygen ion that makes up water is not what aquatic life breathes in order to exist. It is the dissolved oxygen (DO) which is a gaseous form found in the air we breath. Two main sources of DO in water come from diffusion of air with the water and through photosynthesis of aquatic plants such as phytoplankton (microscopic plants).

DIFFUSION of water with air occurs with the water surface being exposed to the air. This diffusion is increased with wave action or there is agitation of the water surface to allow more contact with air.

PHOTOSYNTHESIS is a process by which plants manufacture food. Aquatic plants use nutrients, carbon dioxide, water and energy from sunlight to produce food. A waste product of this photosynthesis process is oxygen which is dissolved in the water. Photosynthesis is the primary source of DO in pond water. In a healthy, properly constructed and managed pond there is usually enough dissolved oxygen to sustain fish life the year around without any problems.

Pond water oxygen levels throughout a 24 hour period will fluctuate. The highest concentration is in mid-afternoon and lowest at sunrise. The reason for this is that during daylight hours photosynthetic activity occurs and reaches its peak in the afternoon. During the night this activity ceases due to lack of light and DO levels fall. Photosynthetic activity is not as great on cloudy days as sunny days.

The amount of DO water can hold depends on barometric pressure and decreases as the altitude above sea level increases. As temperature of water increases the amount of DO decreases with cold water being able to hold more DO than warm water.

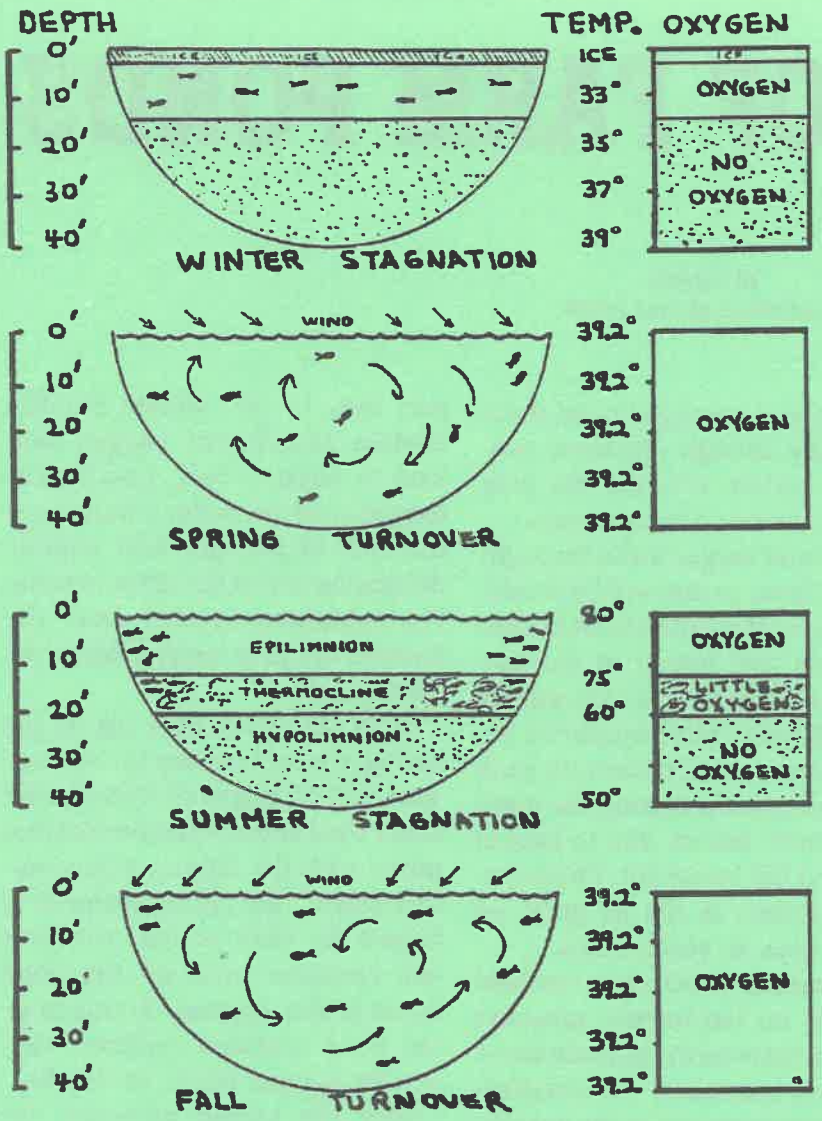
STRATIFICATION

Depending upon depth and location, many ponds will stratify as to water temperature and dissolved oxygen. Pond water tends to go through an annual cycle of temperature and DO variations corresponding with the seasons. (See figure 1) The temperature/oxygen cycle begins when the pond is covered with ice and is dormant. The water at the bottom is 39.2 degrees F., (water reaches its maximum density or weight at this temperature) and the water above is colder but lighter, with the lightest water just under the ice. During this winter stagnation, the upper portion of the pond contains sufficient oxygen for fish, while the deeper part may in late winter months contain insufficient oxygen and food to support fish. Insufficient oxygen in deeper water results from the lack of sunlight and organic decomposition at the lower depths. Phytoplankton located near the surface produce oxygen when receiving light.

When the ice breaks up in the spring, the sun warms the surface water to 39.2 degrees F. This heavier water then sinks to the bottom and mixes with the lighter, colder waters below. This spring turnover is helped by wind action: turnover will continue until all the pond water is 39.2 degrees. At this time, the pond contains sufficient oxygen for aquatic life at all depths.

After the spring turnover, the water continues to warm as the season progresses. The warm water stays on top and does not mix with the colder water below. The pond tends to separate into a warmer upper layer (epilimnion) with adequate DO, which floats on the lower, colder layer (hypolimnion) with little or no DO during the summer. Between these two layers is another thinner layer of intermediate temperature and less oxygen known as the thermocline. When this happens the pond is stagnated as the water does not mix from top to bottom. The bottom layer may be completely devoid or have very little oxygen for fish survival.

The cold nights of fall bring the reverse of the spring turnover process. The surface temperature becomes cold, sinks and mixes with



Cycle of annual water conditions in a pond or lake.

FIGURE 1

the deeper water until all the water is at the maximum density (39.2 degrees F.) In this fall turnover stage, oxygen is present again at all depths so that fish and animal life can be found in all portions of the pond.

MAJOR CAUSES OF OXYGEN DEPLETION

Introduction of organic wastes like run-off from feedlots, animal manure, die-off of dense aquatic plants including algae and phytoplankton create an increased demand by bacteria for dissolved oxygen when they decompose. Annual accumulation of organic sediment in the pond bottom from dead fish and other aquatic animals, dead plants, pollution, run-off from the Periods of watershed, etc. requires oxygen for decomposition.

Periods of hot weather in large expanses of shallow water or extended ice and snow cover during the winter will also contribute to the depletion of oxygen. As the DO falls below critical levels, fish become distressed and eventually die if the level continues to fall. Optimum DO levels for fish range from 5- to 12-parts per million (ppm). If the DO falls below 5 ppm fish are stressed and start dying of asphyxiation. Cold water fish like trout require a higher level (6 or 7 ppm). However, the minimum level required to support fish life will vary with the species, size, and age of the fish; with temperature; and with the concentration of other substances. Temperature effects the amount of DO water can absorb and the rate at which fish can use it.

SUMMER KILLS

Summer kills of fish often occur in shallow water ponds or ones that have low water levels during periods of hot weather. The temperature of the water becomes very warm. Warm or hot water doesn't hold much dissolved oxygen as cooler or cold water. With the decaying of organic material on the pond bottom the DO is soon depleted. Fish then start dying.

WINTER KILL

Winter kill of fish occur in ponds that have a build up of organic materials on the bottom and when there are extended periods of ice and snow cover. Long periods of cloudy weather will hasten the process. Snow cover will shut out sunlight to the aquatic plants (phytoplankton) living below the ice and causing their death. (See figure 2) Opaque ice will also do the same. When this happens decay of these plants and other organic material use up the dissolved oxygen causing the fish to suffocate. Shallow ponds and those that have a lot of organic material built up in the bottom mud are more susceptible to winter kill. Heavily stocked ponds used in commercial fish production can also be more susceptible to winter kill.

SUDDEN DIE OFF OF AQUATIC PLANTS

Die off of aquatic plants can produce oxygen deficiency through the decaying of the dead plants. Sudden die offs usually occur in ponds

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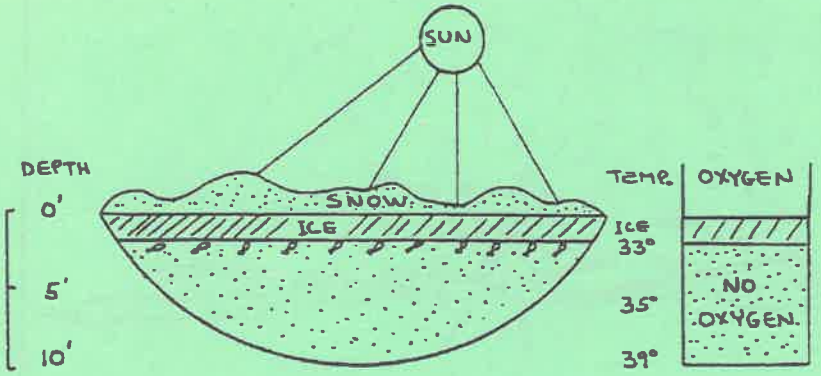
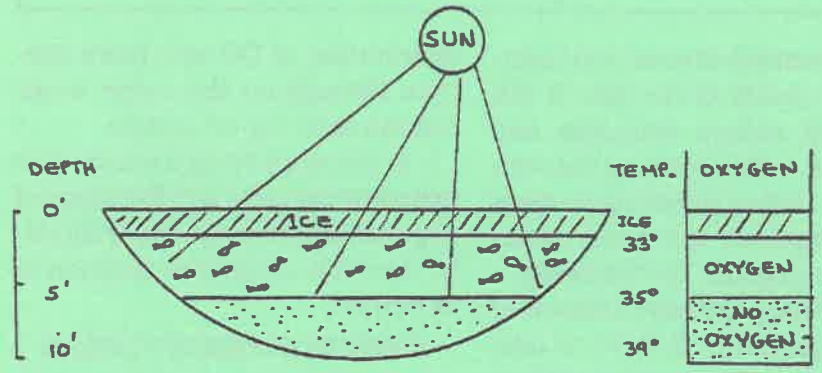


CONDITIONS NECESSARY TO PRODUCE A WINTERKILL OF FISH



CONDITIONS NECESSARY FOR FISH SURVIVAL

POND CONDITIONS IN WINTER

FIGURE 2

with dense algal blooms and after heavy cold rain or high winds that break up the thermal stratification resulting in complete mixing like a spring or fall turnover. If the pond has a large volume without DO this turnover can reduce oxygen at all levels enough to produce a fish kill.

Surface temperature warms rapidly which is less dense than cooler water in the deeper portions of a pond. This deeper water may contain little or no oxygen. When heavy cold rains or heavy winds occur the pond water becomes mixed from top to bottom resulting in less oxygen throughout which can result in a fish kill.

SIGNS OF OXYGEN DEFICIENCY

Low DO levels will cause fish to congregate at surface gasping for air; they will not eat food where fish are being fed; and large numbers of aquatic animals like crayfish will leave the pond. With plankton die-off the water may become gray or brown in color. Die-off of large amounts of scum type filamentous algae floating on the surface will be an advance warning that there may be problems of adequate dissolved oxygen.

SIMPLE TEST FOR OXYGEN DEFICIENCY

William McLarney in his book on aquaculture described a simple test that a pond owner can do to determine if there is oxygen deficiency. Obtain a long oak pole and clean and sand it the entire length. The pole should be long enough to reach from the top of the water to the bottom of the pond. This is then stuck into the water vertically to the bottom mud and left there for 45 minutes. When the pole is removed the portion that is stained is where severe oxygen depletion is occurring. Dissolved oxygen testing instruments used by more sophisticated anglers are also available on the market to test for the amount of DO at different water depths.

WAYS OF PREVENTING OXYGEN DEPLETION

REDUCE AQUATIC VEGETATION GROWTHS. Aquatic plants will provide food and cover for fish. When plant growth becomes excessive it is then that some control measures should be used. It is the excessive growths that can cause oxygen problems. Aquatic vegetation can be controlled with the use of proper herbicides. Dense blooms of phytoplankton should also be reduced by herbicide treatment. Care must be taken to treat only portions of the area to prevent oxygen depletion through the decay of these plants. Dense blooms of plankton are a sign of a very fertile pond.

KEEP POLLUTANTS FROM ENTERING POND. As mentioned previously pollutants like barn yard wastes entering a pond undergo decomposition by bacteria which use oxygen. Such wastes should not be allowed to enter a pond. Heavily fertilized pond watersheds can help produce an over abundance of phytoplankton and algae which can add to the buildup of organic deposits in the bottom mud. The entire watershed of a pond should be in a permanent grass or timber. Any barnyard or feedlot drainage should be diverted from draining into a pond.

DEEPEN SHALLOW PONDS. Excessive amounts of shallow water can contribute to summer kills of fish. It is also where aquatic vegetation and algae like to grow. When a pond is constructed it should be designed so there isn't a lot of shallow area. In existing ponds the water can be drained and the shallow areas deepened by bulldozing and removing and depositing the soil outside of the pond drainage area.

KEEP SEDIMENT FROM ENTERING POND. Sediments from agricultural watershed can shorten the life of a pond and create shallow water areas. Sediments carrying organic materials will also use up some of the DO. Watersheds should be planted to permanent crop covers.

DURING WINTER REMOVE SNOW FROM THE ICE. Snow is an opaque material that keeps light from penetrating through the ice to the water below contain oxygen producing plankton. By removal it gives an opportunity for light penetration in order to keep the algae (plankton) from dying, decaying and using up oxygen.

MECHANICAL AERATION. Aeration can increase the DO by bringing more water in contact with air. This can be done with paddle wheels, centrifugal recirculating pumps, water sprayed over the surface (fountains), impeller lift pumps, perforated pipes, hoses and special designed devices through which air is pumped to create bubbles through the water. Aeration during the winter months will keep iced areas open and expose more water to air and sunlight.

Besides adding DO to water mechanical aeration will circulate the water column and destratify it so that oxygen will be found at all levels. It will also help prevent winter and summer kills of fish. It may reduce nuisance algae growths. And in commercial fish production with a dense fish population it can help prevent fish disease and maintain the quality of the fish. It will also help reduce ammonia and hydrogen sulfide build up that can be toxic. Before investing in aeration equipment the pond owner needs to consider the following:

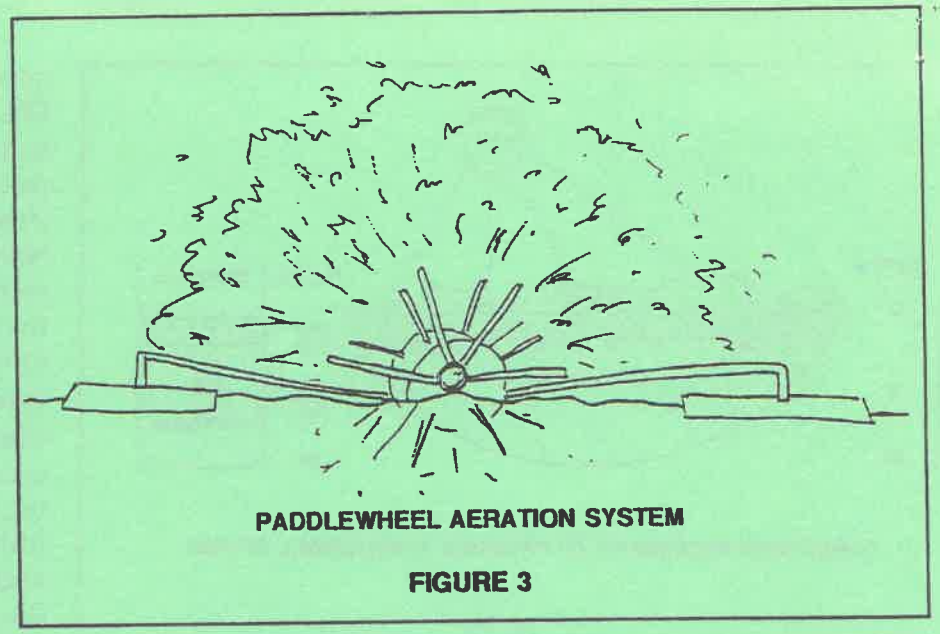
1. Does the pond have a dissolved oxygen problem? If there is adequate oxygen the year around there may be no need for mechanical aeration.

2. Does the cost of the equipment and its operation justify the expenditure? Aeration equipment is expensive and requires maintenance. For most systems electricity will be required.

3. How effective are the different aeration systems? Which one will be the most beneficial to add dissolved oxygen needed for a specific size pond. Small ponds (2 acres or less) will require one aerator whereas larger ponds and lakes will require several to be effective.

4. Will aeration cause more problems? Breaking up the stratification through aeration in a pond where the deeper and greater volume of water has little or no oxygen can reduce the entire DO to levels where fish may be stressed. Bruce Muench in his 30 year study of a two acre pond found that the higher oxygen levels near the surface became less with aeration and the distribution of DO was more uniform throughout the entire water column from top to bottom.

5. Is the pond being used to raise fish commercially? Are fish stocked in great numbers and fed artificially? In such situations aeration is desirable.



PADDLEWHEEL AERATION SYSTEM

FIGURE 3

TYPES OF AERATION SYSTEMS

Aeration can be divided into four major types. Waterfalls at oxygen as the water is broken up over the falls. Waterfalls are not usually found in ponds. Paddle wheels that churn the surface of the water to add oxygen. Water pumps that spray the water above the surface will add oxygen. Air compressors pump air into the water adding oxygen. The latter three are mechanical devices that can be installed in a pond and are usually operated by electric motors. Electricity will have to be available at the pond site.

PADDLE WHEEL (Figure 3): A wheel with several paddles attached operated by an electric motor splashes large volumes of surface water into the air. The splashing water will pick up gaseous oxygen from the air. It also circulates the water. Claude Boyd of Auburn Alabama University found that this

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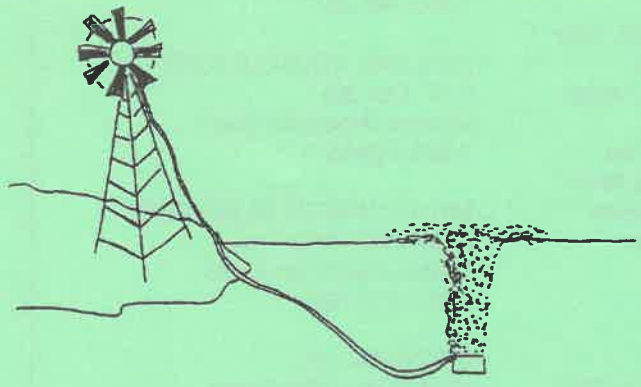
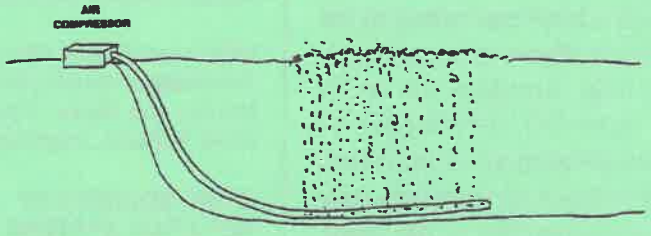


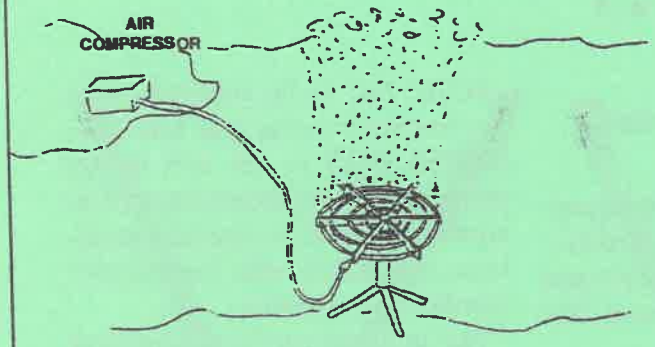
WINDMILL AIR SYSTEM

FIGURE 4



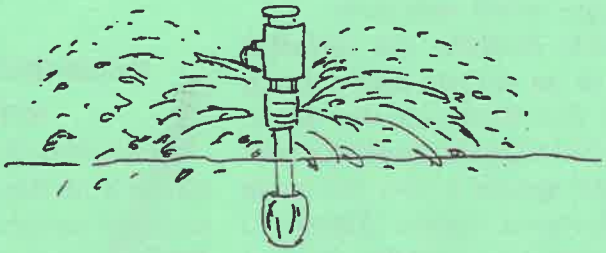
PERFORATED AIR HOSE SYSTEM

FIGURE 5



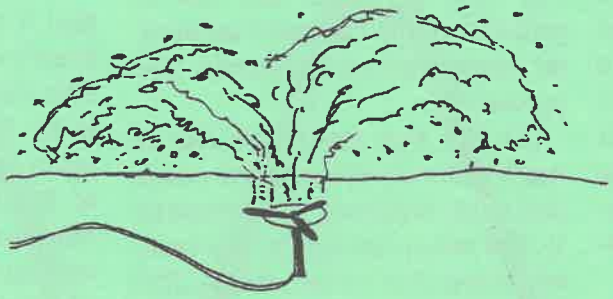
DIFFUSER AIR SYSTEM

FIGURE 6



FLOATING WATER PUMP SYSTEM

FIGURE 7



WATER FOUNTAIN

FIGURE 8

system added more dissolved oxygen to the water than any other.

AIR COMPRESSORS: A windmill is dependant upon adequate wind to operate the aeration system. Wind strikes the mill blades turning a crankshaft to a connecting rod attached to a diaphragm. The diaphragm produces pressurized air through a hose extending to the pond bottom where it is released. This will help circulate the water and add more DO. (See Figure 4.) Electrical operated air compressor designed to force air through tubing or pipes extending to the pond. The tubing with numerous tiny holes may be placed on the bottom or suspended below the surface. The air is released through the holes causing bubbles to rise to the surface. (Figure 5.) Some systems used a specially designed diffuser to produce the air bubbles. (Figure 6.) Some diffusers are designed to mix air add water under pressure creating a greater turbulence to increase the dissolved oxygen. These are called aspirators.

WATER PUMPS: An impeller pump is an electric motor driven device that floats on the water, brings water from beneath the surface and sprays it into the air to add dissolved oxygen. (Figure 7.) There are water fountains that can be installed in a pond to spray the water into the air thus adding oxygen. Figure 8. Water pump aeration devices will create convection currents to circulate the water on the surface as well as from top to bottom.

Mechanical aeration of ice and snow covered ponds seems to be most beneficial to ponds subject to winter kill. Aeration will add DO and melt a portion of the ice cover creating an open water area. Year around aeration may not be beneficial except in the cases of commercial fish production.

❑

REFERENCES

Boyd, Charles 1979 ***Water Quality in Warmwater Fish Ponds.*** Auburn University, Auburn, Alabama

Muench, Bruce 1997 ***Stick Your Head Under the Surface.*** Muench Books, Marengo, Illinois

MClarney, William 1984 ***The Freshwater Aquaculture Book.*** Hartley and Marks, Publishers Point Roberts, Washington

SOME SOURCES OF AERATION SYSTEMS

AQUATIC ECO-SYSTEMS, INC.
1767 Benbow Court Apopka,
Florida 32705-7730
1-800-422-3934

FRESH-PLO CORPORATION
W 4915 Highway 28
Cascade, Wisconsin
1-800-493-3040

STONEY CREEK EQUIPMENT COMPANY
11073 Peach Avenue
Grant, Michigan 49327
1-800-448-3873

HEDLUND AQUACULTURE
P. O. Box 305
Medford Wisconsin 54451
1-800-723-6011

MALIBU WATER RESOURCES
27004 Sea Vista Drive
Malibu, California 90265
1-310-317-1624

GROVHAC, INC.
4310 North 126th Street
Brookfield, Wisconsin 33005
1-414-781-5020

OTTERBINE BAREBO, INC.
3840 Main Road East
Emmaus, Pennsylvania 18049
1-610-965-6018

New Netting cont. from p. 5

K-LESS (KNOTLESS) POLY NETTING

The use of K-LESS POLY in aquaculture is on the increase. Producers in the catfish, crawfish, koi and goldfish areas have all seen this material in action.

Made from 100 percent toray fiber polyethylene, the K-LESS nets are knotless, twisted and slick to the touch. These nets set the commercial shrimp industry's standard for excellence in fuel consumption. The ease at which they can be pulled through the water astounded many veteran fishermen and producers.

The fact that these nets can be made into square-meshed seines and pens furthered their versatility. Not woven like fabric, but twisted strand into strand, the K-LESS all polyethylene seines and pens allow maximum water flow and a slick, fish friendly environment.

NOTE: Not to be confused with the coarser raschel type knotless, K-LESS POLY is flat and tightly woven. It has very little if any stretch and has none of the elasticity problems associated with the cheaper raschel polyethylene.

This material can be washed free of algae and scum quite easily. It is stronger than knotted polyethylene of the same size by 20 percent. In square mesh, it can he opened almost 100 percent full. allowing maximum water flow.

The K-LESS cage or pen is so light that 6 ft x 4 ft x 3 ft pens can he floated with 1 inch PVC frame work. This netting absorbs no water due to its 0.95 specific gravity. Once again, in square mesh, the number of filled or "ring-necked" fish is reduced by 75% over conventional netting, due to the absence of knots and the permanently slick surface of the Toray fiber polyethylene.

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