LIVE-HAULING

CHANNEL CATFISH

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DIVISION of AQUACULTURE
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Live-Hauling Channel Catfish

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Introduction

Catfish are transported and sold live to processing plants, fee-fishing operations, recreational lakes or to live-fish markets. Those who transport live fish are commonly referred to as “live-haulers.” Live-haulers provide the vital link between catfish producers and their markets. Depending on fish size and number, catfish are transported in containers that range from plastic bags to insulated tanks mounted on tractor-trailers (Fig. 1). Technologies can be as simple as using table salt to reduce fish stress during handling and transport or as advanced as liquid oxygen systems.

Transporting live fish is a risky business. Properly equipped and well-maintained trucks are essential to success (Fig. 2). The drivers must have the appropriate licenses and

Figure 1.

Large trucks equipped with fish-transport tanks can move catfish long distances if properly prepared and monitored during transit.

permits for the vehicles they are driving, and be aware of state and federal laws regulating the transport of live fish (See Permits, page 25). He or she must be comfortable with transporting containers filled with liquid and live fish — often for long hours. Live-haulers must have experience in handling and transporting live catfish and some knowledge of water chemistry. The driver and the truck must arrive at the destination safely, and on time with the fish in

Figure 2.

Medium-sized trucks can deliver fish to small ponds and negotiate tight turns on pond levees.

good condition. While enroute, frequent stops to check on the condition of the fish and equipment will often determine the safe delivery of healthy fish.

Marketing Fish to Processing Plants

Foodsize catfish of 1.0 to 4.0 lbs are transported and sold live to processing plants. Direct sales of catfish to U.S. processors accounted for 94 percent of larger, farm-raised catfish, 1.0 to 3.0 lbs, sold in 2004. Recreational, live-haulers, retail, agencies and other uses

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Figure 3.

A pickup with gooseneck trailer can haul a number of fish tanks.

accounted for the remaining sales (NASS 2005). Catfish sold to processors are delivered and held in trucks or off-loaded into concrete holding vats at the processing plant. Fish are transferred to the processing line as needed. Catfish processing plants are located near larger fish-production operations. Close proximity to catfish farms reduces travel time and expense when delivering fish from ponds to processing plants. Commercial production ponds and the holding vat facilities of the plant are typically designed to accommodate large, live-fish transport trucks. Depending on the capacity of the processing plant, the trucks may range from 1 ton (2,000 lbs), (Fig. 3), to a tractor-trailer weighing over 20 tons.

Dead catfish and those of poor quality will be rejected at the plant before they are unloaded from the truck. Processing plants may penalize growers that supply large volumes of undersized or oversized fish. In recent years, pond-bank prices paid by processors for live catfish have ranged between $0.50 – $0.80 per lb. Taste-testers check for off-flavor fish from each load at the processing plant. Fish may contain a number of undesirable odors and tastes which make them unmarketable for days, weeks or even months. The off-flavor is concentrated in the fish flesh from certain species of algae and bacteria but is harmless to the health of the fish or to humans. Rejected fish are returned to the production pond until their flavor improves. Environmental factors in the pond determine the duration of the purging process. See Tucker and Van Der Ploeg (1999) for more information on off-flavor in catfish.

Marketing Fish to Fee-Fishing Operations and Live Markets

Live catfish are also sold to live-fish markets, fee-fishing operations or stocked into recreational fishing ponds. Depending on the market, these fish may be larger or smaller than those sold to processing plants. These loads may contain fish less uniform in size. Some catfish producers transport their own fish, while others sell their fish to live-haulers. Often, these fish may be transported for longer distances than those sold to processors. Live-haulers selling fish to these markets often receive a higher price than those sold to processing plants.

Regardless of where food-size catfish are sold, they should first be taste-tested to prevent the sale of off-flavored fish. Unfortunately, off-flavor catfish are sometimes sold to live markets and fee-fishing facilities since they would be rejected by processing plants. These fish may be consumed by customers before the flesh is purged of the off-flavor compounds. Intentionally selling customers off-flavor fish is a poor business practice that damages consumer opinion of the product. Fishermen are unlikely to return to a fee-fishing lake if the fish they caught and paid for were off-flavor.

Harvesting Catfish

Feed is withheld from catfish one to five days before transport, depending on water temperature. This prevents deterioration of water quality due to the build-up of nitrogenous wastes during transport. Catfish of all sizes are harvested by seining and are often graded through mesh-net devices referred to as “live-cars or socks.” These live-cars are attached to the throat of the seine. The larger, harvestable fish remain in the live-car after grading and are dipped out by the seining crew into a loading net. The loading net is attached to a digital scale that is hooked to the cable of a boom truck. When the water is drained out of the loading net, the fish weight is recorded and the net is positioned over the transport truck's hauling tank. A door is opened in the bottom of the loading net that releases the fish through a top door in the tank (Fig. 4). In order to avoid injuring fish sold to live markets, fish are transferred into the tanks at a rate of 200-300 lbs-per-basket load. Larger loads – which speed up the harvesting process – are often used when fish are sold to processing plants.

Diseased fish should not be harvested or transported because excessive mortality may occur. Fish recently treated with antibiotics, and some other chemicals, must be held in the pond for the proper withdrawal time before they are sold for human consumption. Fish health records should be made available to customers before they are transported from the farm.

Figure 4.

Catfish are loaded into fish-transport tanks from a loading basket attached to a boom truck. A digital scale is used to weigh the fish.

CHANNEL CATFISH

Water Quality and Loading Rates

Ideally, catfish are transported in clean, oxygenated well water at a temperature of 50 - 60° F. Desired water quality parameters for transporting live catfish are provided in Table 1 (Jensen 1990b).

Table 1. Transport water quality parameters for catfish (Jensen 1990b).	
Dissolved Oxygen	>5 mg/L
Carbon Dioxide	<20-30 mg/L
Total hardness	50-100 mg/L
Total Alkalinity	50-100 mg/L
pH	7.0 -7.5

Before loading, the weight of fish to be transported must be known in order to determine the water volume required for the duration of the trip. Approximately 8 lbs of fish displaces approximately 1.0 gal of water inside the hauling tank compartment (Jensen 1990c). Care must be taken not to overload the transport tanks with fish. This decreases the water volume of the tank below that required for safe fish transport, which increases stress and may cause mortality. Live tank loading rates are influenced by many factors, such as the trip duration, size and condition of the fish, water temperature, the outside air temperature and whether they are transported in tanks equipped with an aerator/agitator or pure oxygen aeration system. Foodsize fish may be stocked at a greater weight per gallon of transport water than fingerlings or stockers (fish weighing less than 1 lb). Smaller fish will consume more dissolved oxygen than an equal weight of larger fish (Piper, et al. 1989). Table 2 provides loading rates for catfish of different sizes. If transport time exceeds 12 hours, the loading rate should be decreased by 25%. Loading rates should be decreased by 50% for trips exceeding 16 hours unless transport water is exchanged during the trip.

Table 2. Recommended transport densities (lbs/gallon) for different sized catfish loaded per lb in 65°F water for three trip durations (Piper et al 1989)

Number of Fish Per Lb	Transport Period in Hours		
	8	**12**	**16**
1.0	6.30	5.55	4.80
2.0	5.90	4.80	3.45
4.0	5.00	4.10	2.95
50	3.45	2.50	2.05
125	2.95	2.20	1.80
250	2.20	1.75	1.50
500	1.75	1.65	1.25
1,000	1.25	1.00	0.70
10,000	0.20	0.20	0.20



Non-chlorinated ice may be added to the tanks during hot weather to keep the transport water cool. This reduces fish metabolism and increases the amount of dissolved oxygen the water can hold. Ice may be added at a rate of 0.5 lbs per gallon of transport water. This will reduce water temperature by approximately 10° F (Jensen 1990b). Adding 1 lb of ice will lower the temperature of 10 gallons of transport water approximately 2° F. Standard catfish loading rate recommendations are made for transport water at 65° F. Loading rates must be reduced approximately 25% for every 10° F increase above 65° F. Loading rates may be increased proportionately for similar decreases in water temperature.

As a general rule, 4 lbs of foodsize channel catfish can be loaded per gallon of transport water aerated with atmospheric oxygen (21%). To estimate a loaded transport volume (fish + water), 1/3 of the space is occupied by fish and 2/3 is water. Therefore, loading rates are calculated on 2/3 of loaded tank volume. For a 1,000 gallon loaded volume, 667 gallons of water (2/3 X 1,000) are available to be loaded with 2,668 lbs of catfish (667 gal X 4 lbs).

Using pure oxygen gas, 5 lbs of 1-2 lb catfish may be transported for every gallon of hauling water at 65° F. However, that slightly changes the volume relations discussed above: approximately 4/10 (0.38) of loaded volume (fish + water) is fish and 6/10 (0.62) is water. Using the previous example — a 1,000 gallon loaded volume — 600 gallons of water (6/10 X 1000 gal) are available to be loaded with 3,000 lbs of catfish (600 gal X 5 lbs).

Sterilizing Tanks

Live-haul tanks should be sterilized after every load. This prevents the transfer of diseases that may have been present in previous deliveries. Customers will not be happy if you bring a disease problem to their lake that causes fish to either stop biting or die. You can disinfect tanks with chlorine or formalin. A 10 mg/L chlorine solution, 6g per 100 gallons of water for calcium hypochlorite (65% chlorine as active ingredient) is recommended (Masser and Jenson, 1991).

Unscented household chlorine bleach is the easiest to purchase. Completely wash or spray all inner surfaces of the tank with the bleach solution and allow to disinfect for 1.0 hour after application. After 1.0 hour, be sure to thoroughly rinse with water all surfaces that were in contact with bleach solution. Allowing bleach residue to remain could harm fish placed in the tanks for your next delivery. Bleach can be corrosive to metal surfaces.

Truck Size

Fish-hauling trucks may range in size from a pickup truck that can transport 100 gallons of water (approximately 833 lbs) to a tractor-trailer that can haul 5,000 gallons (roughly 45,000 lbs). Table 3 provides truck size and recommended hauling tank capacities (Jensen 1990a). Distance to the market, the market location and the volume of fish to be transported will determine the size of the truck needed. Due to confined locations, many urban fish markets, fee-fishing facilities and recreational ponds could not be accessed by a tractor-trailer for delivery. Unlike a large processing plant, it is unlikely that the majority of these markets would take delivery of 20,000 lbs of catfish at one time. Straight, flat-bed trucks with beds measuring 18–26 feet are commonly used. A four-wheel drive, one-ton pickup truck equipped with a fifth wheel hitch and a trailer equipped with live tanks may transport 5,000-6,000 lbs of fish in one load when using liquid oxygen. Trucks using detachable trailers have the advantage of being available for other uses when not hauling fish.

Table 3. Truck size and recommended hauling tank capacities (Jensen 1990a)

Truck size (short ton: 2,000 lbs)	**Tank capacity** (gallons)
0.50	100
0.75	300
1.0	400
1.5	600-800
2.5	1,200
Tractor-trailer	5,000

Transport Tanks

Fish-transport tank capacities may range from 75 to 2,500 gallons. Most tanks hold between 100 and 300 gallons. Transport tanks are rectangular and equipped with insulated top doors for loading (Fig. 5). Most tanks are constructed of aluminum, fiberglass or plywood covered with fiberglass. Aluminum is more durable than fiberglass and these tanks may better withstand the wear and tear of frequent loading and off-loading large fish. However, fiberglass tanks tend to remain cooler during hot weather and may be more appropriate for transporting fish over long distances (Fig. 6). Inside the outer shell of the tank, two inches of pour–in polyurethane foam, or other material, encases the inner compartment liner to insulate it from outside temperatures. The use of insulated tanks is particularly crucial for transporting fish over long distances in hot weather. Non-insulated tanks made of steel, wood or fiberglass may be used for transporting fish for short distances, often to fish processing facilities.

A protective mat made of rubber or insulation material is placed between the bottom of the transport tank and the deck of the truck to prevent wear from road vibrations. Larger transport tanks should contain internal baffles to help reduce water surge inside the tank. Excessive water surge — the sudden forward movement of the water — must be limited because it decreases braking efficiency by increasing the distance needed to stop the vehicle. Overflow ports are often installed in tanks where agitators are used to maintain acceptable levels of carbon dioxide. These ports prevent the filling of tanks to full capacity, which would eliminate the air space needed to allow gas exchange at the surface of the water. Tank drains must be wide enough to allow the discharge of large catfish. Slide gates are installed behind the tank drains to hold back the fish and water when the drain gate is removed for unloading. Installing drains on one side of the tank allows all the fish to be released from the same side of

Figure 5. Small aluminum pickup truck transport tank

the truck without having to turn the truck around. Tank floors should slope towards the drains to help facilitate the discharge of water and prevent fish from becoming stranded (Jensen 1990a). An aluminum chute or large diameter PVC pipe is attached to the tank drain and is used to discharge the fish and water into a holding vat or pond. Dip nets, buckets, hand tools, and a hanging scale should be carried on the truck at all times. A 1- to 2-inch, 12 V submersible or portable gasoline pump should be carried on the transport truck to replace and exchange tank water, and to acclimate fish to different temperatures when needed.

When stocking catfish into ponds, approximately one-half of the hauling water should be replaced with receiving water if the difference in water temperature is more than 10^{o}F, or more than one unit in pH. Allow approximately 30 minutes for the fish to acclimate in the tank for each 10^{o}F difference in water temperature or for each unit difference in pH. This process allows the fish to acclimate to water quality changes between the transport and receiving water. Unfortunately, this practice is rarely adopted.

Figure 6. Large fiberglass tanks installed on a flatbed trailer

Use of Aeration, Pure Oxygen, Compressed Oxygen and Liquid Oxygen

Aeration

Catfish are delivered to processing plants at high densities (5 to 8 lbs/gallon) to lower transport costs. Trip durations of one to four hours are typical. Fish in the transport tanks are supplied with air provided by diesel-powered regenerative blowers (Fig. 7), (Bosworth et al. 2004). Ambient air delivered from the blower is distributed to the tanks by air hoses or plastic tubing.

Figure 7.

Truck equipped with air blower and liquid oxygen

Air flow meters mounted on the outside wall of the transport tank monitor air flow into each compartment. Tubing enters the container through a port and is connected to a weighted, medium-to-coarse-pore air diffuser, located on the tank bottom. Fine-pore diffusers such as those used for oxygen will clog and should be avoided. Electric agitators (Fig. 8) or air blowers are commonly used to enhance carbon dioxide removal and aerate live-fish transport tanks. While these devices are practical and readily available, they can have some disadvantages: high initial investment, possible equipment failure, and they may cause the water temperature to rise more rapidly during transport (Fig. 9).

Figure 8.

Electric agitators

Figure 9.

Electric agitators in tanks

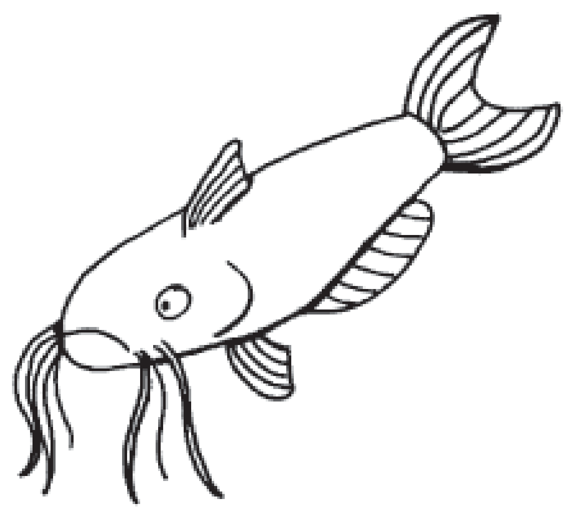
Using Pure Oxygen

The use of pure oxygen for fish transport has become commonplace. There are several advantages with this method: equipment can be leased; there is little chance of equipment failure; it may reduce water temperature somewhat; and water turbulence is limited. By using pure oxygen gas and carefully monitoring DO, standard loading recommendations may be increased by 25%.

Heavily loaded tanks require pure oxygen flow rates in the range of 3-6 liters/minutes of oxygen gas for each 100 gallons of fish-transport water. Actual flow rates will vary from load to load and must be adjusted up or down accordingly. Care must be taken not to supersaturate the transport water with oxygen. This could result in excessive oxygen use, and dead or injured fish. Dissolved oxygen concentrations in water are determined by water temperature, local altitude and salinity. For example, 100% saturation with dissolved oxygen in 68°F water at sea level and zero salinity would be 8.84 mg/L. The saturation concentration decreases as water temperature, elevation and salinity increase. Using pure oxygen (90-100%) versus atmospheric oxygen (approx. 21%) can cause higher concentrations of oxygen to dissolve in water than are possible naturally. Super-saturating the water with oxygen — forcing more oxygen into the water than it would normally hold — may interfere with the fish's ability to process the excess oxygen taken up by the gills. Excess gas may concentrate in the blood causing "gas bubble disease" which may be lethal in severe cases. The driver should frequently check dissolved oxygen with a dissolved oxygen meter throughout the duration of the trip to ensure that each tank has the proper dissolved oxygen concentration (Table 4). Oxygen flow rates should be changed when problems develop. For information on using dissolved oxygen meters, their maintenance and the various models available, see "Measuring Dissolved Oxygen Concentration in Aquaculture" by Hargreaves and Tucker (2002).

Table 4. For the following temperatures, dissolved oxygen (DO) in freshwater transport tanks should be maintained within these ranges.

Temp (F)	Dissolved Oxygen (mg/L)
60°	6.4-9.9
65°	6.2-9.5
70°	5.8-8.9
75°	5.4-8.4
80°	5.2-8.0



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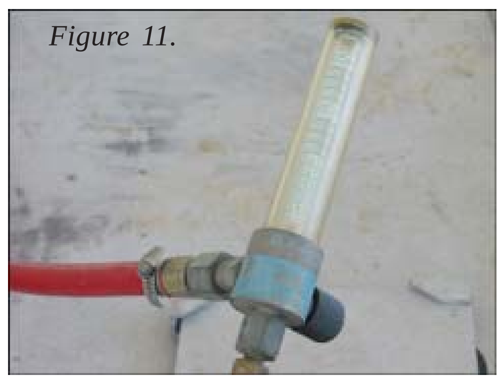
Oxygen is introduced into the water as fine bubbles through porous materials such as air stones or diffuser hose. Dissolved oxygen concentrations are partially dependent on bubble size; smaller bubbles produce higher concentrations. Oxygen is released from the bottom of the tank through fine-pore diffuser systems configured into a weighted grid. These are made from diffuser rods or stones made of ceramic, plastic, bonded glass, carbon or other materials. Fine-pore diffusers should be used to create a small bubble size that transfers oxygen to the water efficiently. Ultra-fine-pore devices may clog too frequently. Diffusers must be inspected, cleaned and maintained before each trip to avoid stressing or killing fish during transport. Soft, fine-pore diffuser hose may be used; however, sharp catfish spines may abrade or puncture the hose and limit the effectiveness of this material. Diffusers are readily available from commercial suppliers who can help you select the correct pore size.

Figure 10.

Liquid O^2 line with O^2 flow meters

Figure 11.



Oxygen flow meters

Oxygen concentrations in hauling water can be adjusted up or down by increasing or decreasing gas flow rates with a regulator valve and a flow meter. Side-mounted flow meters located on each tank are used to determine the proper flow rate of oxygen into each tank (Figures 10-11). Oxygen levels below the minimum recommendation may stress or suffocate fish. Levels above the maximum recommendation could cause gas bubble disease or tissue damage. Pure oxygen gas can be distributed to live-haul tanks from compressed gas cylinders or liquid oxygen tanks.

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Carbon dioxide in the hauling water should be monitored when using oxygen (liquid or compressed gas). Aquaculture water quality kits are commercially available from several suppliers. These kits contain easy-to-use tests for measuring carbon dioxide concentrations as well as for other water quality parameters. The release of fine-oxygen bubbles from the diffusers does not agitate the water sufficiently to drive carbon dioxide gas out of solution. Carbon dioxide tends to accumulate reducing oxygen availability to fish during long trips if water is not exchanged. Although carbon dioxide acidifies and reduces the percentage of the toxic un-ionized ammonia in transport water, it may interfere with the ability of fish blood to carry oxygen. If accumulation is slow and oxygen levels are adequate, channel catfish will tolerate 20-30 mg/l of carbon dioxide. Tank vent funnels and electric (12V) agitators mounted through ports located on the top of transport tanks (Fig. 9) can be used to help drive off carbon dioxide gas. However, this will drive off oxygen as well.

Compressed Oxygen

Compressed oxygen gas is available in steel cylinders which are commonly used for welding (Fig. 12). These cylinders are available in a number of sizes containing from 3,455-13,820 liters (122-487 cubic feet) of compressed gas. Cylinders containing 3,455 and 6,910 liters are relatively easy to handle. (Fig. 13). Oxygen in compressed gas cylinders can be stored indefinitely. Compressed gas cylinders are generally used for short trips on small scale transport trucks and trailers:

- at 3 liters/min-100 gal — a 6,910 liter cylinder would supply oxygen to 1,000 gallons of transport water for 3.8 hours.
- at 6 liters/min-100 gal — a 6,910 liter cylinder would supply oxygen to 1,000 gallons of transport water for 1.9 hours.

Figure 12.

Gooseneck trailer with tanks and compressed O^2 bottles

Liquid Oxygen

Liquid oxygen systems are typically used when hauling catfish long distances. Long drives are common for live-haulers whose business involves stocking lakes and ponds for recreational fishing. Liquid oxygen is stored in a dewar (Fig. 14) and is released by a low-pressure regulator into the transport water as oxygen gas. A dewar is a container that maintains the liquid oxygen's cold-storage temperature by thermally insulating its contents from the outside environment with a vacuum space. The vacuum space is created between inner and outer container walls

Figure 13.

Oxygen bottle with regulator

similar to those of a beverage Thermos. It may weigh 780 lbs and supply 4,500 ft^3 of gaseous oxygen (Jensen 1990a). One or two dewars are often fastened to the center, or the rear of the truck bed. Liquid oxygen is more expensive, $0.07 or more per ft^3, than aeration provided by regenerative blowers. Water temperatures remain cooler longer with liquid oxygen as opposed to aeration. This is because liquid oxygen is very cold and the gas is still cool when released. Also, there is limited water contact with the air outside the hauling tank.

Lower water temperatures help slow fish metabolism, maintain higher levels of dissolved oxygen, and lower the percentage of toxic un-ionized ammonia present. Liquid oxygen cannot be stored indefinitely as approximately two percent of liquid oxygen is vented daily as it warms and is released from the dewar (Fig. 14).

A 160-liter (42 gallon or 5.6 cubic foot) liquid oxygen container will supply approximately 127,000 liters of oxygen gas. That would supply:

- at 3 liters/min-100 gal; 1,000 gallons of transport water for 70.5 hours.
- at 6 liters/min-100 gal; 1,000 gallons of transport water for 35.3 hours.

Reducing Handling and Transport Stress

Live-haulers must be exceptionally careful when their cargo is destined for pay lakes. Transporting channel catfish to Kentucky fee-fishing operations (pay lakes) may take from 4 to 24 hours. Catfish must arrive healthy and ready-to-catch or anglers will not pay to fish. Stressed fish are difficult to catch and do not provide much sport.

Various chemical additives have been used to transport live fish. Currently, the only FDA-approved additives recommended for food fish transport are food-grade salts. Sodium chloride – table salt – is the most common. Several other biologically important salts are also used.

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Catfish and other vertebrates have a unique and common characteristic. The salt content of their blood is almost identical. Vertebrate blood has a salinity of approximately 9 g/l (a 0.9% salt solution) and a pH of 7.4. Approximately 77% of the salt in blood is sodium and chloride. The remainder is made up primarily of bicarbonate, potassium and calcium. Sodium and potassium salts are critical for the normal function of heart, nerve and muscle. An 8 g/l (0.8%) salt solution made with table salt (sodium chloride) would match the sodium content of blood.

Figure 14.

Liquid oxygen is stored in a dewar.

Fish blood is brought into close contact (1- or 2-cell separation) with the environment as it flows through the small blood vessels of the gills and skin surface. Salts diffuse from areas of high concentration (blood) to areas of low concentration (fresh water). Therefore, salts are slowly but continuously lost to the environment. Lost salts are replaced by reabsorbing them from the water or during food digestion. Body energy is used to replace salts.

The gills and skin of fish are coated with a thin layer of mucus which helps reduce the loss of salts to the surrounding fresh water. Netting or handling removes some of the protective mucus coating. Transferring and shipping catfish to and from ponds and live-haul tanks require handling which causes stress. The strain of transport and loss of mucus from the skin causes fish to lose important body salts from their blood. This increases stress on fish that are already weakened. If too much salt is lost, fish can experience heart failure as well as serious nerve and muscles spasms. The addition of sodium chloride limits or prevents (depending on concentration) the loss of body salt during transport.

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Very litttle salt loss occurs in a 9 g/l salt solution because the concentrations of the transport solution and blood nearly match. The addition of salts to transport water at concentrations close to 9 g/l helps stop or minimize salt loss by reducing or eliminating concentration differences between fish blood and environmental water. This reduces energy demands and diffusion leakage while providing a large supply of environmental salts for re-absorption and replacement of lost blood salts.

In combination with handling stress, salt concentrations of 10 g/l (1.0%) or greater in transport water could be harmful to fish during live transport. This could cause fish to become dehydrated. A 10 g/l salt solution is approximately 10% higher than blood. Therefore, it would be advisable to use transport solutions containing less than 9 g/l salt. An 8 g/l sodium chloride solution in transport water nearly matches blood sodium content but is slightly lower than 9 g/l. This lower salinity helps prevent dehydration and shock by keeping kidneys active and salt loss low.

Traditionally, 0.5 to 2 g/l (0.05 to 0.2%) sodium chloride solutions have been used to reduce stress during fish transport. Some of Kentucky's live-haulers use 5 to 8 g/l (0.5 to 0.8%) sodium chloride mixtures and have had excellent success transporting channel catfish and other species. An 8 g/l solution is formulated by dissolving 6.4 lbs of food grade sodium chloride (feed mixing salt or table salt) in each 100 gallons of unloaded water (no fish) or 4 and 3/4 level teaspoons in each gallon (Table 5). It is important to remember that salts are highly corrosive to metal surfaces (e.g. truck beds, chassis and body).

Table 5.

Types, concentrations and quantities* of food-grade salts used in live-fish transport water.					
Chemical name	Common name	Concentration	Teaspoons per gallon	Cups per 100 gallons	Pounds per 100 gallons
Sodium chloride	feed mixing or table salt	8 g/l (0.8% salt)	4 3/4	9 3/4	6.4
Calcium sulfate	agricultural gypsum	125-250 mg/l (as CaCO3)	1/4 - 2/5	1/2 - 4/5	0.18 - 0.36
Sodium bicarbonate	baking soda	100-200 mg/l (as CaCO3)	1/8 - 1/4	1/4 - 1/2	0.14 - 0.28
* Amounts listed assume a starting concentration of zero (none present). For accuracy, concentrations should be checked before, during and after the addition of each salt. Use level household measures.					

Other food-grade salts can be added in combination with sodium chloride to improve the quality of fish transport water (Table 5). Research has shown calcium hardness helps control leakage of blood salts and is required for their re-absorption. The desired range of calcium hardness is 125-250 mg/l; 250 mg/l calcium hardness equals the calcium concentration in blood. Food-grade calcium sulfate (agricultural gypsum) will increase calcium hardness. Also, shipping water should have desirable concentrations of pH (7-8) and bicarbonate alkalinity (100-200 mg/l). Respiratory carbon dioxide can accumulate in transport water and lowers pH. Bicarbonate alkalinity helps to prevent pH from dropping. Sodium bicarbonate (baking soda) will raise bicarbonate alkalinity and pH.

Transporting Channel Catfish Fry and Fingerlings in Plastic Bags

Foodsize and fingerling catfish are transported by truck in large tanks. Hauling fish of these sizes requires considerable investment in equipment and a large truck. However, shipping fry and 1- to 2-inch fingerlings can be accomplished effectively in a van or small truck using plastic bags, Styrofoam ice chests and pure oxygen gas. Large numbers of small catfish fingerlings and fry may be transported at a fraction of the cost and risk when compared to larger fish. With increasing costs for fingerling transportation, it may be beneficial for some growers to produce their own fingerlings by stocking ponds with fry or small fingerlings to produce fish of stocking size. When they reach approximately 6.0 inches in length, these fish could be grown to harvest size or transferred to other ponds containing mixed sizes of fish.

Large plastic bags (18 X 32 inches) are commonly used for fish transport. Four-cornered bags are preferred to avoid corner collapse which can suffocate large numbers of fry that become trapped when pockets form. Bag thickness should be 4 mil to help minimize punctures. Bags are usually doubled to ensure that they remain air tight if one should leak.

The plastic bags are filled with water, fish and oxygen gas. Typically, each bag is filled such that 1/4 of the volume is water (2 gallons is common) and 3/4 will be oxygen. Water and fish are added. The remaining air is removed by hand, compressing or squeezing it from the bag. The bag is completely refilled with pure oxygen gas. Oxygen is added through a flexible tube attached to a small compressed gas cylinder. The neck of the bag is twisted and then sealed tightly with one or more large rubber bands or livestock castrator bands (Figures 15-17). The number of fish placed in each bag is determined by fish size and weight, and estimated travel time (Table 6).

Table 6.

Pounds **p**er **g**allon* of fish that can be transported in bags for several shipping times

Fish Size	**Travel Time (Hours)**			
	1	**12**	**24**	**48**
Eggs	0.5 - 1.5	0.5 - 1.2	0.5 - 1.0	0.2 - 0.5
Yoke-sac fry	1.0 - 3.0	0.7 - 2.5	0.4 - 2.0	0.1 - 1.0
Swim-up fry	0.5 - 2.0	0.4 - 1.6	0.4 - 1.2	0.2 - 0.6
1- to 2-inch fingerlings	1.0 - 3.7	0.9- 3.2	0.7- 2.7	0.3 - 1.3

Adapted from Dupree and Huner (1984) * At a water temperature of 65^{o}F.

Figure 15.

Bag thickness should be 4 mil.

Figure 16.

Fill w/ water, fish & oxygen gas.

Figure 17.

Twist & seal w/ large rubber band.

The data in Table 6 were presented by Dupree and Huner in 1984, and are for a variety of fish species. The fin spines of 4- to 10-inch catfish fingerlings readily puncture bags and make transport by this method risky. A reasonable but conservative loading rate (24-hour transport) for channel catfish fry is 1/2 lb of fry to each gallon of bagged water (Table 6). There are approximately 10,000 catfish fry to the pound. Two gallons of water would be required to ship 10,000 channel catfish fry on a 24-hour trip (1/2 lb fry/gal X 2 gal X 10,000 fry/lb). The presence of organic substances in shipping water – material released by hatching eggs or feces from fish fed less than 12 hours, before transport – reduces the load capacity. Ice or freezer gel packs can be added to an insulated shipping container (ice chest) to help keep the water temperature close to 65^{o} F.

Shipping water should have several desirable chemical characteristics: pH, 7-8; bicarbonate alkalinity, 100-200 mg/l; and calcium hardness, 125-250 mg/l. Because the bags are sealed, respiratory carbon dioxide accumulates in the water and lowers pH. Bicarbonate alkalinity helps to prevent pH from dropping. Sodium bicarbonate (baking soda, 1/8 to 1/4 tsp/gal) will increase bicarbonate alkalinity and pH. Food grade calcium sulfate (gypsum, 1/4 to 4/10 tsp/gal) will enhance calcium hardness. Adding 0.2 to 0.5% sodium chloride (table salt, 1-1/4 to 3 tsp/gal) is the standard recommendation for fry and small juvenile catfish. Water quality parameters such as alkalinity, hardness, pH and salinity may be tested with aquaculture test kits available from several commercial suppliers of aquaculture equipment.

LIVE-HAULING

Once fish have arrived at their destination, they should be tempered to their new environment as soon as possible. Float the bags in the new water (pond or tank) for 30 minutes to allow bag temperature to equilibrate with environmental temperature. It is advisable to place the bags in an area where they are not in direct sunlight. Resist the temptation to open the bag and aerate it with a bait agitator or air stone. The buildup of carbon dioxide during transport lowers the pH of bag water. Aeration will rapidly remove carbon dioxide and simultaneously increase pH. A sudden change in pH can shock and kill the fish. After the 30-minute acclimation period, open the bag and gradually mix the bag water with new water, and then release the fish.

Fish Transportation & Live Fish and Bait Dealers Permits

Currently, a Transportation Permit (fee: $25.00) must be obtained from the Kentucky Department of Fish and Wildlife Resources for all individuals and businesses that haul live fish into, through or within Kentucky. A transportation permit is not required by those that hold a Kentucky Fish Propagators permit except when transporting fish into Kentucky from out of state. Additionally, a Live Fish and Bait Dealers license must be obtained by anyone selling fish in Kentucky, or out of state. Contact the Kentucky Department of Fish and Wildlife Resources by phone at 800-858-1549 for permit applications and more detailed and updated information. Out-of-state fish and game agencies will likely require a permit to deliver fish within their respective states. In some instances, a permit may be required to transport fish through some states. Contact the appropriate state fish and game agency for a fish transportation permit before entering that state with live fish. The illegal interstate transport of live fish is a violation of federal law and may result in a large fine.

CHANNEL CATFISH

Summary

Production and markets are important components of all businesses. Distribution is the critical third element. Without a system of distribution, it would not be possible to get products to their markets. In the world of Kentucky catfish aquaculture, the farmer and ponds are production. Fee-fishing lakes and – to a lessor degree – processors are the markets. Live-haulers are the distribution system. Without live-haulers, the Kentucky fee-fishing industry could not exist.

As you have learned in this publication, live-hauling can be a fairly technical enterprise. The right equipment, good water quality, plenty of oxygen, a little salt and careful attention to detail help to ensure the delivery of healthy, high-quality fish. Cutting corners can cause the death of a load of fish, resulting in the loss of money and customers. Healthy fish that are easy to catch shortly after delivery make for happy consumers and fishermen, satisfied fee-fishing operators and a successful live-haul business.

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NOTES

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