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Transportation of Warmwater Fish: Equipment and Guidelines

Forrest S. Wynne and Dr. William A. Wurts[1]

The link between fish harvest and distribution to market is transportation. Fish are transported for re-stocking, brought to market to be sold live, or delivered to processing plants for slaughter. At this stage, most labor and production costs have already been incurred, and any fish loss from death or injury severely affects the profit margin.

Most fish losses from hauling stress are caused by poor water quality and improper handling. Outbreaks of latent diseases or osmoregulatory problems may also occur. Osmoregulation is the ability of the fish to maintain proper internal salt concentrations. Poor water quality, overcrowding, and improper handling or tempering may cause serious fish losses or injury. The goal is to provide healthy fish that survive until they are sold and processed or after they are re-stocked.

The type and size of transport equipment will be determined by the scale of the market and the quantity of fish delivered. The methods used for transporting fish must ensure that high-quality fish are brought to market and that it is done safely, meeting all state and federal regulations.

Water quality

Water quality must be managed carefully while fish are crowded and stressed during hauling. The major water quality factors that limit the loading densities of fish are adequate concentrations of dissolved oxygen (DO) and the build-up of toxic waste products, such as ammonia and carbon dioxide. Temperature, pH, loading density, fish condition, and trip duration affect these two factors and the problems they may cause. For more information on transport water quality and loading rates for different fish species, see SRAC Publications 392 and 393.

A suitable water supply is needed for short-term holding and hauling. Cool, uncontaminated well water is preferred. Well water must be aerated thoroughly to remove carbon dioxide and increase DO before it is used in transport tanks. Beware of high levels of ammonia and iron that can occur in well water. Iron can be removed by aerating water and letting it settle before use. However, if ammonia and iron concentrations are high, it is better to use a more suitable water source.

Pond water is less desirable for transport because it contains algae, micro-organisms, and organic compounds that can remove oxygen from the water and produce ammonia as a waste product. Pond water is more likely to have harmful fish disease organisms than well or spring water. If necessary, clear pond water without a heavy algal bloom can be used for short trips, but special care is needed to ensure that no harmful contaminants or unwanted organisms are present. Surface water may be filtered with a saran sock when filling the transport tanks to reduce the potential of transporting unwanted aquatic species.

Fish condition

Only fish that are healthy and in good condition should be hauled. Tolerance of loading and transport stress varies with fish size and species (see SRAC Publication 393). Some species are hardy, and others require special precautions. With so many important variables affecting fish transport, it is imperative that the hauler understand which loading rates are acceptable under

[1]Kentucky State University Cooperative Extension Program

specific conditions. Begin with conservative loading rates and adjust practices over time, based on experience and observed outcomes.

At the beginning of a trip, the DO in the loaded tanks should be checked often with a DO meter to ensure that aeration and oxygenation equipment (and O_2 flow rates) are working properly. Fish respiration may decrease somewhat an hour or two after loading. After that, fish can be checked and the DO adjusted less often.

Fish may die from the shock and disease caused by transport stress. Little can be done to save fish that go into shock. It is not uncommon for fish to develop disease problems a few days to 3 weeks after delivery if they were significantly stressed during transport. Transport stress is caused by netting, handling, crowding, jostling, imbalance and loss of body salts, temperature change, and water quality/chemistry problems that develop during a trip. Handling and stress trigger the release of bio-active compounds that can affect critical organ functions and water/salt balance. While anesthetics can be useful for calming excitable species of fish and reducing injuries, anesthetics can also produce a biological response similar to that caused by stress. Adding salt (food-grade sodium chloride) to live transport tanks at the right concentration will help minimize the effects of transport stress. For more information about using anesthetics, salts and other additives in fish transport water, see SRAC Publications 392 and 393. Following the correct transport practices and using the right equipment can substantially improve fish condition and survival during transport and after delivery.

Hauling tank systems

The hauling unit should be compatible with its intended use. Water is heavy—1 gallon weighs 8.3 pounds. A light pickup truck can handle a 100-gallon tank, while a ¾-ton pickup can pull a gooseneck trailer with two 350-gallon tanks. The following table shows appropriate tank capacities for various truck sizes.

Truck size (short ton)	Recommended tank capacity (gallons water)
Tractor-trailer	5,000
2.5	1,200
1.5	600-800
1.0	400
0.75	300
0.5	100

Some tanks are attached directly to the trailer frames or flatbed trucks, while others are portable and can be removed from the trucks or trailers. Gooseneck trailers equipped with electric-over-hydraulic or vacuum-over-hydraulic brakes are used to carry transport tanks. The pickup truck that pulls the gooseneck is then available for other purposes (Fig. 1). Producers who regularly haul large quantities of fish often use specially designed, self-contained transport vehicles (Fig. 2). A producer can save money by purchasing used equipment in good condition.

For safety reasons, follow the gross weight limits for vehicles and the tonnage weight for trailers. It is unsafe and illegal to overload trucks and trailers. Lateral water movement within fish transport tanks may make maneuvering the truck difficult. The forward movement of water, or surge, while braking increases vehicle stopping distance and creates a safety hazard.

Each state regulates the transport of live fish within its borders. Permitting agencies such as departments of fish and game, conservation, natural resources, or transportation determine fees, regulations and restrictions.

Figure 1. Pickup truck towing a gooseneck trailer with aluminum transport tanks.

Figure 2. Semi truck-trailer carrying fiberglass transport tanks with round drain plugs and liquid oxygen dewars.

These may vary from one state to another. Check with your state's fish and game agency to determine which agency(s) issues permits for transporting live fish. The Lacey Act is a federal law that regulates the interstate transportation of live fish, dead fish, and game animals. To avoid potential fines, the proper permits must be obtained for both intrastate and interstate transport of live fish. With each load of fish, carry the proper permitting paperwork, bill of lading, and required truck signage to comply with state and federal regulations.

Fish hauling tanks come in various sizes and designs. In the South, most hauling tanks are insulated unless trips are short or tanks are for on-farm use only. Insulation prevents tank water temperatures from changing too quickly. Polyurethane foam is often used as insulation between tank walls. Tank capacities range from 75 to 2,500 gallons, but 100- to 300-gallon tanks are most common. Tank depth is usually 28 inches to 32 inches. Most tanks are rectangular and have one to eight compartments in varying arrangements. More than one compartment is needed if several fish sizes or species are to be transported at the same time. Large or long tanks must contain baffles to reduce water surge that can injure fish and create dangerous driving conditions. Welds in single, long tanks may break if the truck bed flexes. This can be avoided if smaller, standard tanks with the same carrying capacity are placed side by side.

Most tanks are made of 3⁄16-inch aluminum or ¼-inch fiberglass. Un-insulated fiberglass or stainless steel tanks work well for short trips. Metal tanks are less likely to be broken or damaged. Any hardware on the tank should be aluminum, stainless steel, or other rust-resistant material. The top door or lid of the tank should be large if fish will be loaded with a boom and fish basket. Large doors make fish removal easier if dip netting is required.

The tank drain can be located in the rear or on the side of the tank. Side outlets make it easy to unload fish to holding vats or ponds by means of chutes or extended discharge pipes. These help reduce the rough handling caused by dip-netting. The discharge opening should be large enough to allow easy passage of the largest fish hauled; it should be equipped with a quick-release stainless steel dump gate or an expansion plug (Fig. 3). Drain openings can be rectangular (12 inches long by 8 inches wide) or round (usually 3 to 8 inches in diameter). A sliding inside gate, over the drain opening, helps control the rate of discharge and allows the outside dump gate or expansion plug to be removed without releasing water or fish (Fig. 4). A sloped inner tank bottom ensures that the tank will empty completely with minimal extra handling. The bottom of the drain opening should be flush with the tank bottom. Tanks should be outfitted with an overflow drain to maintain

Figure 3. Rectangular steel dump gate on aluminum tank.

Figure 4. Slide gate located on the inside of a fiberglass tank.

Figure 5. Agitators and electrical connections on an aluminum pickup truck tank.

water level and allow agitators to function at the proper operating depth. Outdoor electrical outlet boxes and plugs should be available for the easy connection of agitators (Fig. 5). A central junction box with wires leading to individual outlets works well.

Although uncommon in the South, tanks may have clear, vertical tubes or panels for determining fish weights with calibrated water displacements rather than by scale weighing. This method requires that water transfer with fish be minimized. It is commonly used in the trout industry where fish pumps and dewatering towers are used to move fish from production or holding units to transport tanks. Handling is minimal and efficient.

Figure 6. Liquid oxygen (LOX) dewar.

Oxygenation and aeration systems

A variety of methods can be used to aerate water during hauling. Because fish are densely crowded and excited—especially after loading—it is essential that the aeration system provide adequate DO rapidly and efficiently. Maintain an oxygen concentration of at least 6 mg/L or parts per million (ppm) at all times. Higher oxygen levels, near air saturation, may help fish cope with the physiological stress of unavoidable ammonia build-up, especially during long trips.

To lower transportation costs, catfish are loaded at high densities (5 to 10 pounds/gallon) in aerated tanks for delivery to processing plants. Trips typically last 1 to 4 hours. The transport tanks are supplied with air from diesel-powered regenerative blowers. Air from the blower is distributed to the tanks by air hose or plastic tubing. 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 medium- to coarse-pore air diffuser on the tank bottom. Fine-pore diffusers, such as those used for liquid oxygen (LOX) systems, will clog and should not be used.

Most large hauling trucks use LOX. A LOX dewar (tank) supplies about 4,500 cubic feet of oxygen and weighs about 780 pounds (Fig. 6). A LOX dewar is more expensive than a compressed oxygen tank, but LOX is cheaper per cubic foot of oxygen than compressed oxygen gas, weighs less, and fewer tanks are needed to supply the same amount of oxygen. LOX should not be stored for long periods because about 2 percent of the gas is lost daily through pressure release valves.

For small fish loads and short trips, compressed oxygen is adequate. A standard oxygen cylinder holds about 280 cubic feet of compressed oxygen gas and weighs about 150 pounds (Fig. 7). Other sizes of oxygen cylinders are also available. Compressed oxygen can be stored indefinitely.

Both kinds of oxygen tanks can be leased or purchased. Consider cost, needs, service and convenience in deciding which oxygen source to use. Follow all recommended safety precautions when using pure oxygen. Fish transport trucks carrying liquid or compressed oxygen must be licensed with the Department of Transportation (DOT) and follow the proper regulations for transporting flammable materials.

Figure 7. Compressed oxygen gas cylinders mounted on a trailer.

Single-stage pressure regulators are needed for each oxygen tank, and each aeration line to a tank compartment should have a flow meter (lpm) to adjust supply rates.

Various diffusers are used for dispersing oxygen into the transport tank from the bottom of the compartment. Fine-pore diffuser stones and cylinders made of ceramic, rubber poly (EPDM), aluminum, or Bioweave™ and other diffuser tubing work well (Fig. 8). Aeration lines from the regulator to flow meters and drop lines to the diffusers are usually ⅜-inch ID flexible plastic tubing or PVC pipe. Some diffusers have stainless steel frames with diffuser hoses that fit into the bottom of each tank compartment. Oxygen diffusers do not remove carbon dioxide efficiently. But under high-density hauling conditions, diffuser systems supply oxygen effectively.

Agitators are used alone or in combination with pure oxygen. Agitators can also provide back-up aeration in emergencies. For short trips, agitators alone may suffice. The combination of agitators with oxygen diffusers works well. Agitators do not mix water well, so there may be low DO in corners of the hauling tank. There should be one agitator per compartment. Excessive agitation can be harmful to delicately scaled fish such as shad. Diffused oxygen is preferred for small fish.

Most agitators are 12-volt direct current (DC) units powered by the vehicle's battery and alternator. Alternators should be heavy-duty, and the vehicle's engine should be kept running during short stops to keep the battery charged.

Figure 8. Diffuser hose grid on the floor of a fiberglass tank.

Other equipment and supplies

If you sell fish in small lots along a route, an easily attached or extendable support for a hanging scale is useful. The scale should be certified for trade, calibrated in pounds and ounces, and have a weighing bucket or basket. A suitable dip net is needed to transfer fish.

It is important to measure oxygen concentrations and water temperature during transport. A reliable oxygen meter is essential.

Gauges and manifolds that indicate the functional status of agitators and flow meters can be put inside the truck cabin. Flow meters can also be located for easy visual inspection to make certain oxygen is supplied at all times during the trip.

Haulers need test kits for water hardness, alkalinity, and pH so they can check transport and receiving waters, especially if fish are transported from hard, highly alkaline water to soft, acidic water. If you deliver fish to sites where chlorinated water is used, a chlorine test kit is helpful. Sodium thiosulfate can be used to dechlorinate water at a ratio of 1.6 to 2.6 mg sodium thiosulfate/L to 1 mg chlorine/L, depending on the water pH.

Carry at least one extra agitator, a set of hand tools, and essential spare parts such as fittings and hoses. A 12-volt submersible pump or gasoline-engine pump is useful for adding water in an emergency. These pumps are also useful for tempering fish at the stocking site by replacing one-third to one-half of the tank's water volume with pond water. This allows for a slow exchange and mixing of water within the transport tank and minimizes the risk of shock caused by differences in temperature and water chemistry.

Pre-hauling handling and planning

Fish must be healthy and in good physical condition before they are loaded into transport units. A load of fish in poor condition may die during transport or suffer excessive mortalities after stocking. Withhold food from fish for at least 1 to 2 days before transport during warmer months and for 3 days or longer during colder weather. Fish with empty stomachs are hardier because the energy they would have spent digesting food can be used to adapt to a stressful environment. Un-fed fish will not regurgitate food in the transport unit and will produce less waste. Do not starve cannibalistic fish such as striped bass or red drum longer than 3 days before harvest.

If possible, use V-traps or harvest basins as water levels are lowered in ponds to harvest small, fragile, scaled fish. Use soft, 3⁄16-inch, knotless, nylon mesh nets for delicate minnows.

Harvest large fish by seining or trapping. Select the proper mesh size and net material for harvest seines and dip nets to avoid injuring or gilling fish. Use treated nylon or polyethylene nets for seining catfish. Polyethylene nets do not require special treatment. For more information on harvesting warmwater fish, see SRAC Publication 394.

After fish are harvested, and when time and water quality conditions allow, carefully remove debris and give fish a resting period of several hours before they are handled again. If holding vats are available, you can easily grade, clean and sort fish before shipment. For more information on sorting and grading warmwater fish, see SRAC Publication 391. Fish may be slowly tempered or acclimated to the expected transport water temperature. Fish should be tempered for ½ hour for each 10 °F difference in water temperature or one unit change in pH.

If fish are to be held in ponds, maintain adequate aeration and water quality. Secure live cars or harvesting seines to the pond bottom. Avoid holding large fish or active species in cages. Do not overload cages. If fish begin to die, diagnose the problem, take corrective action, and return fish to the pond rather than transport them.

Prophylactic treatment with approved chemicals can reduce pathogenic organisms that could cause problems during or after transport. Paracide-F® may be used in holding vats for 15-minute to 1-hour baths. Do not use excessive doses or combinations of chemicals. Be prepared to flush any treatment with fresh water if fish show any signs of stress. Only chemicals approved by the Food and Drug Administration (FDA) can be used in water containing food fish.

Transport trucks, tanks and other equipment, such as dip nets and air stones, should be scrubbed, dried and disinfected between loads of fish. This reduces the possibility of spreading disease pathogens from one group of fish to another. Tank compartments can be scrubbed with detergent, sprayed and rinsed with 250 mg/L of iodine, rinsed, then air dried. Dipnets and other equipment may be cleaned with detergents, rinsed, dried, and disinfected with sodium or calcium hypochlorite, formalin, or iodine solutions. For more information on disease control and cleaning and sterilizing transport trucks, hauling tanks, and fish handling equipment, see SRAC Publication 4703 and NRAC Publication 201-2009.

To avoid untimely delays, get good directions to your destination and carry detailed maps and/or a global position system (GPS) device. Plan your trip to include any drop-offs or water exchanges. Be certain that all required permits or licenses are in order and are in the vehicle in case of an inspection.

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