



## AQUACULTURE EXTENSION

*Illinois - Indiana Sea Grant Program*

Sea Grant # II-IN-SG-FS-913

Fact Sheet AS-462-W



TRANSPORTATION

# *Transport of Fish in Bags*

**LaDon Swann**

*Illinois-Indiana Sea Grant Program*

Purdue University

## **Introduction**

Fish, shellfish, and plants are often transported in sealed plastic bags containing small quantities of water and pure oxygen. Bag shipment requires placing a prescribed weight of fish in 1.5-2 gallons of water in a large plastic bag. Excess air is removed from the bag and replaced with pure oxygen. The bag is sealed and placed into an insulated container and finally into a cardboard shipping box and shipped.

There are several reasons why bag shipment may be the best choice for the shipper. First, very small fish and fry could be damaged by attempts to ship quantities of them in large tanks. Second, due to the extreme distances involved, bag shipment may offer economic advantages to shipping by air freight or bus. This fact sheet will focus on transport of fish, but with minor modifications such as reduced water for plants, the techniques and principals discussed would also apply to shellfish and plants

## **Water Quality During Shipping**

While in the plastic bags during the transportation process, fish health will be affected by changes in various water quality parameters. The parameters to be considered are temperature, dissolved oxygen, pH, carbon dioxide, ammonia, and the salt balance of the fish's blood. The rate of change of each parameter will be affected by the weight and size of fish to be transported and the duration of transport. Each water quality parameter will be discussed and methods of delaying the negative effects will be presented.

## **Temperature**

Fish are cold-blooded; as a result, the metabolic rate of fish will be affected by the temperature of their environment. The metabolic rate of fish will double for each 18°F increase in temperature and be reduced by one-half for each 18°F decrease in temperature. A reduced metabolic rate will decrease the oxygen consumption, ammonia production, and carbon dioxide production. It is, therefore, essential to transport fish at low temperatures. For cool- and warmwater species a temperature of 55°-60°F is recommended. Coldwater fish such as trout inhabit colder water and naturally should be transported at even colder temperatures such as 45°-50°F.

To achieve the desired transport temperature, fish should be held in tanks that have access to cool water. By holding the fish in tanks for two days, the water temperature can be gradually reduced with additions of cool water from the cleanest available source. After loading the fish into bags final decreases and maintenance of temperatures during transport can be accomplished through additions of ice, or more commonly with the use of blue ice packs,

Ice or the blue ice packs are often used during transport, especially over longer transport periods that might allow increases in temperature. One-half pound of ice will reduce the temperature of one gallon of water by about 10°F. Insulated Styrofoam shipping boxes are also used to prevent outside temperatures from influencing the temperature of the transport water. In certain instances, ice coolers are used for transport.

## Dissolved Oxygen

The most important single factor in transporting fish is the provision of adequate concentrations of dissolved oxygen (DO). The importance of supplying adequate levels of dissolved oxygen cannot be overemphasized. Failure to do so results in severe stress and possibly hypoxia or buildups of blood lactic acid which may contribute to fish kills two to three days after stocking.

The amount of oxygen that can be dissolved in water is based on water temperature. When the upper level is reached the water is referred to as being "saturated with oxygen." DO saturation is higher for cool water than for warm water. For example, at sea level DO saturation of 45°F water is 12.1 parts per million (ppm) while at 60°F saturation is 10.0 ppm. Because pure oxygen is used during bag transport, DO levels in the water will be saturated and the low oxygen levels will usually not be a problem, unless the bag is improperly sealed or develops holes caused from the spines of large fish. It is important to have a 75% volume of oxygen in the bag to insure adequate diffusion of oxygen at the surface of the water.

## pH

The quantity of hydrogen ions (H+) in water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. A value of 7 is considered neutral, neither acidic nor basic; values below 7 are considered acidic; above 7 basic. The acceptable range for fish growth is between pH 6.5-9.0. The pH of water will be influenced by the alkalinity (buffering capacity) and the amount of free carbon dioxide. The pH of the transport water will also affect the toxicity of ammonia. Even in well-buffered transport water the pH will sometimes decrease by one pH unit.

## Carbon Dioxide

As fish respire they produce carbon dioxide as a by-product of respiration. Carbon dioxide will react with water to form a weak acid. This weak acid will in turn decrease the pH of the water. High levels of carbon dioxide (greater than 20 ppm) will interfere with the oxygen uptake in the fish's blood. High levels of carbon dioxide are sometimes found in well water. Excess carbon dioxide in well water can be reduced through mechanical aeration or by passing the water through a degassing column.

## Ammonia

Ammonia buildup occurs in transport water as a result of fish metabolism and bacterial action on fish wastes excreted into the water. Two forms of ammonia occur in transport water, ionized and un-ionized. The un-ionized form of ammonia (NH<sub>3</sub>) is extremely toxic while the ionized form (NH<sub>4</sub><sup>+</sup>) is not. In tests for ammonia, both forms are grouped together as "total ammonia." The percent of ammonia that is un-ionized will depend on both temperature and pH (Table 1).

Table 1. Percent of ammonia in the un-ionized form at different temperatures (°f) and pH values.

pH	Temperature				
	50	55	60	65	70
6.0	0.02	0.02	0.03	0.03	0.04
6.5	0.06	0.07	0.09	0.11	0.17
7.0	0.19	0.24	0.29	0.34	0.43
7.5	0.59	0.74	0.93	1.07	1.33
8.0	1.83	2.30	2.87	3.31	4.10
8.5	5.56	6.92	8.54	9.78	11.90
9.0	15.70	19.00	22.80	25.50	29.90

Total ammonia concentrations may reach more than 14 ppm during transport. However, the percent of the total ammonia which is un-ionized at pH 6.5 and 55°F is 0.07%. Therefore, un-ionized ammonia at 14 ppm is  $14 \times 0.0007 = 0.0098$  ppm. It is recommended that total ammonia concentrations greater than 5 ppm (0.015 ppm un-ionized at 60°F and pH of 7.0) be viewed with caution.

The easiest way to reduce toxic ammonia buildup in transport water is *to lower the temperature of the transport water and to stop feeding several days before transporting*. Fish up to 8 inches should not be fed for 48 hours before loading and transporting and those larger than 8 inches should be off feed 72 hours before transporting.

## Chemical Additives

Numerous chemical additives can be added to the transport water to alleviate several problems associated with transporting fish in sealed bags. Because overdoses of chemicals can result in death, care must be taken when measuring the dosage of each chemical used. It is essential to double-check every calculation and to use an accurate balance before adding chemicals.

The most common chemical added to transport water is salt (NaCl). Salt is used to relieve stress associated with maintaining a water balance in the fish. Fish have a blood salt concentration higher than the salts of the transport water. Concentrations of 5,000 ppm (0.590) are commonly used. A 5,000 ppm concentration can be made by adding 19 grams of salt per gallon (g/gal.) to water used during transport. The type of salt to use should be non-iodized containing no anti-caking compounds. Canning salt is a good example.

If the water alkalinity of the transport water is less than 100 ppm, some type of buffering-compound should be added to the water. Properly buffered water will help remove free carbon dioxide which causes drops in pH. Sodium bicarbonate (Na<sub>2</sub>CO<sub>3</sub>) is one of the fastest reacting buffers and should be added at a rate of 1 g/gal. of water.

Finally, because fish are transported in crowded conditions, stress will be placed on them. Sometimes a chemical anesthetic may be beneficial by producing a light sedation. The only Food and Drug Administration (FDA)-approved anesthetic for food fish is Finquel (tricaine methanesulfonate). Finquel may be used at a rate of 0.1-0.5 g/gal. of water.

### Carrying Capacity

The maximum weight of fish that can be safely transported within a given period of time is the carrying capacity. Carrying capacity depends on the duration of haul, water temperature, fish size, and fish species. If water quality conditions such as temperature, oxygen, carbon dioxide, alkalinity, and ammonia are constant, then carrying capacity will depend on the fish species. In general fewer pounds of smaller fish than larger fish can be transported per gallon of water. General carrying capacity guidelines are given in Table 2. It is important for first time shippers, or experienced shippers transporting new species, to run test batches before undertaking any large shipment.

### Transport Procedure

Days before the actual loading and transporting is to occur, the shipper needs to determine the carrier to be used, time of departure, time of arrival, and shipping costs. This information needs to be communicated to the receiver well in advance of the shipping date. With proper pre-planning, the risks of unnecessary delays in delivery and pickup are avoided. It is the responsibility of the receiver to contact the shipper in the event of any mortalities which maybe the responsibility of the shipper. All loading should be planned to allow boxes to be shipped as soon after loading as possible,

Procedures for bag shipping of fish arc given below:

1. Carefully add the proper weight of fish to 1.5-2 gal. of clean degassed water. Water contained in the bag needs to be within two degrees of the holding water (Fig. 1.) Any chemicals should be added at this time.



Fig. 1

**Table 2. Carrying capacity in pounds of fishh transported in 18- x 32-inch plastic bags containing 2 gallons of water (about 15 lb.). Water should be moderately hard (80-100 ppm total hardness) and have a temperature range of 55-60°F.**

Stage or Total Length in Inches	Transport Period in Hours			
	1	12	24	48
Eggs	1.0-3.0	1.0-2.0	1.0- 1.5	0.5- 1.0
Fry yolk-sac	2.0-4.0	1.4-3.0	0.8-2.0	0.2- 1.5
Swim-up	1.0-4.0	0.9-3.0	0.8-2.0	0.4-1.4
Fingerlings				
1/2	1.8-5.0	1.5-4.0	1.2-3.0	0.6- 1.5
1	2.0-5.0	1.7-4.0	1.3-4.0	0.7-2.0
2	2.0-7.0	1.8-6.0	1.5-4.0	0.7-2.0
3	2.0-7.0	1.8-6.0	1.7-4.0	0.7-2.0
Large fish	4.0-9.0	3.0-6.5	2.0-5.0	1.0-2.5

<sup>1</sup>Source of information on carrying capacity is from Dupree and Huner, 1984. *Third Report to Fish Farmers.*

2. Bag is deflated to remove air. Bag is then re-filled with pure oxygen. Approximately 75% of the volume in the bag should be oxygen (Fig. 2)



Fig. 2

3. Mouth of bag is tightly twisted and secured with heavy-duty rubber bands (Fig. 3). Castration rings or heat sealing may also be used. Bag is placed inside second bag containing a frozen blue ice pack and sealed.

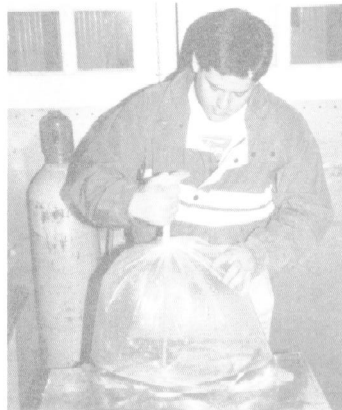


Fig. 3

4. Sealed bags are then placed inside cardboard shipping box and sealed (Fig. 4). The shipping box must be clearly labelled, "Live Fish" and have the name and address of the shipper and receiver. For extended trips, which may experience extremes in heat or cold, the bags may need to be placed inside a Styrofoam cooler before being added to the shipping box.

Proper handling of bagged fish after receiving is as important as pre-handling to insure high survival. Guidelines for post-shipping are as follows:

1. Bags should be floated unopened in a shaded area of the receiving water for 30 minutes to allow temperatures to equalize. Observe for mortalities.

2. Open bags and quickly add 2-3 gal. of receiving water to the bag.

3. Slowly pour fish into the receiving water.



Fig. 4

#### Suggested Readings

Dupree, H.J. and J.V. Hunter. 1984. "Transportation of Live Fish." *Third Report to Fish Farmers*. U.S. Fish and Wildlife Service, Washington, D.C. 156-176.

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

S.K. Johnson. 1988. "Transport of Fish and Crustaceans in Scaled Containers." *Inland Aquaculture Handbook*. Texas Aquaculture Association, College Station, TX. A1504-A1509.

#### Acknowledgements

Appreciation is expressed to Mark Griffin who posed for photographs.