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Shipping Fish in Boxes

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Aquaculture often requires transporting live animals from one place to another. A large shipment of the same type of fish can be delivered via a hauling tank and truck if the distance is not too great. But for long distances, or when the shipment is not large enough to justify a truck with hauling tanks, shipping fish in boxes is a feasible and more economical alternative. For international shipments, air freight in boxes is the only true option. The ornamental fish trade has a long and successful history in using air freight. Today, more and more aquaculture products such as eggs, fry and fingerlings are shipped by air freight in boxes. With modern air transportation, fish can be transported almost anywhere in the world and arrive in healthy condition.

Many factors are involved in successfully preparing, packing and shipping fish in boxes. It is important to keep in mind that once the bags and boxes are sealed, the fish must be able to survive in the container with a minimum amount of stress until they reach their final destination. This publication addresses the major considerations involved in making successful shipments, but because of extreme variations in species, sizes and durations of transport times, it should be used only as a guide.

Limiting environmental factors

The following environmental factors must be within an acceptable range for success. If they reach a critical, limiting level they can cause stress, disease and even mortality. Consider each of these when planning a shipment so that problems can be prevented.

Always start with good quality water. However, as soon as the boxes are sealed many key water quality parameters will begin to change—temperature can go up or down, pH typically will fall, oxygen will be consumed, carbon dioxide will increase, etc. While fish can tolerate some change in their environment, especially for short periods, they do not handle rapid changes well. Water quality parameters can reach critical levels if not managed properly. The goal is to prevent these parameters from changing, or at least manage the rate and degree of change to ensure that fish will arrive in good condition.

Temperature

Fish are cold-blooded animals that cannot regulate their own body temperature. They will be the same temperature as the water they are in. This affects their health in two ways. First, all fish have a defined temperature range in which they thrive and limits at which they can survive. If water temperature deviates from the optimum range, the fish can become stressed; if it deviates beyond their tolerance levels, they can die. Second, fish metabolism goes up as temperature increases and down as temperature decreases. If metabolism increases, many of the other limiting environmental factors will deteriorate more quickly. If possible, fish should be shipped at their lowest optimal temperature to slow their metabolism and decrease the rate at which other environmental factors deteriorate inside the box.

Dissolved oxygen

Dissolved oxygen is often the most important limiting factor in shipping fish. The only source of dissolved oxygen during shipment is the diffusion of oxygen from the air overlying the water within the bag. Because the amount of oxygen in the bag is limited to the volume of the bag, it is essential to maximize the amount of oxygen available during shipment. The main ways to achieve this are to reduce the biomass of fish in the bag, increase the

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amount of oxygen in the bag by using pure oxygen instead of atmospheric air, decrease the length of the shipment time, and decrease the metabolism of the fish by keeping water temperature at the lower level for the given species.

Carbon dioxide

Carbon dioxide is produced by respiration. In a closed bag, carbon dioxide can reach harmful levels that can have a narcotic effect and interfere with the absorption of oxygen by the gills. If the dissolved oxygen level is high when fish are packed it should not be a problem during shipping. Because carbon dioxide in water acts as an acid, it also decreases the pH level, which can be stressful or lethal if allowed to progress unchecked. The main ways to manage carbon dioxide are to reduce the biomass of fish in the bag, increase the amount of oxygen in the bag by using pure oxygen instead of atmospheric air, decrease the length of the shipment time, and decrease metabolism of the fish by keeping water temperature at the lower level for the given species. In addition, buffers can be added to lessen the effect of carbon dioxide on the pH of the water.

Nitrogenous waste/ammonia

Fish excrete ammonia across the gill membrane to rid themselves of nitrogenous waste. Ammonia in water exists in two forms—ionized (NH_4+) and un-ionized (NH_3). Un-ionized ammonia is toxic to fish at very low levels, while ionized ammonia is relatively harmless. The ratio of the two types of ammonia in water is directly related to the water pH and temperature. As pH and temperature decrease, so does the portion of the ammonia that is in the toxic, un-ionized form.

During production, ammonia and other nitrogenous wastes can be managed with tools such as biological filtration. In a sealed bag other methods must be used. The main ways to manage ammonia during shipment are to reduce the biomass of fish in the bag, withhold food from the fish for 24 hours before shipment to reduce the amount of waste they produce, decrease the length of the shipment time, decrease the metabolism of the fish by keeping water temperature at the lower level for the given species, and add a substance to the shipping water to remove ammonia. A combination of methods can be used.

Shipping containers

Shipping fish in boxes typically involves a considerable investment in money, time and effort, so the materials used should be the best available. Packaging materials should be watertight, should prevent rapid changes in temperature, and should be rugged enough to withstand handling during shipping. A plastic bag is the watertight component. It is nestled in an insulated box that protects fish from rapid temperature change. The insulated box is then placed in a sturdy outer box for protection.

Bags

Fish bags are made of transparent polyethylene plastic and should be at least 3 mil thick to withstand some abuse without leaking. Many experienced commercial shippers opt for a more expensive 4-mil plastic bag.

Common “pillow slip” bags have a single bottom seal that creates sharp corners when filled with water. Small fish can sometimes become trapped in these corners during shipment and die. You can “square up” the corners by folding them up and taping them to the side of the bag.

Some bags have square bottoms so that they sit flat on the bottom of the box. Square-bottom bags are more expensive but have become standard in the industry because they do not trap fish in the corners and use the space in the box more fully.

Bags are available in many sizes. Some are small enough to ship individual male betas. There are bag sizes designed to fit snugly in standard size shipping boxes (e.g., full bags, half bags and quarter bags). Bags are available from several Internet sources if there is no retail outlet near you.

Even sturdy, 4-mil bags can be punctured during shipment, so many shippers double- or even triple-bag their fish to ensure that at least one bag will remain watertight. This is a good practice when shipping fish with sharp spines.

Once the bags are filled with water and oxygen (or air), they need to be sealed. While you can simply twist and tie an overhand knot, the method most commonly used is rubber bands. The top of the bag is twisted and then doubled over and the rubber band wrapped tightly around the resulting loop. If rubber bands are used, they should be of a good quality that will not break when significantly stretched. Operations that ship large volumes often speed up packaging by using mechanical clamping machines that crimp a small metal clamp around the bags.

Insulated boxes

Fish boxes are typically insulated to keep the temperature relatively constant during transport. Most are made from polystyrene Styrofoam® that is approximately 0.75 to 1 inch (1.8 to 2.5 cm) thick. Boxes are available in standardized sizes made specifically for transporting fish. They are usually small enough for an individual to easily grip and lift during the handling process. They are available from several Internet sources. A Styrofoam® insulated box protects the outer box from leaks, whereas Styrofoam® panels will not.

Other types of insulation that can be used include inflated “quilted” materials, other rigid insulation panels cut to size, and even newspaper. However, most of these materials are inferior to a Styrofoam® box in insulation value.

Figure 1. Standard Styrofoam® shipping boxes.

Outer shipping box

While Styrofoam® is watertight and provides good insulation, it is not a rugged material and can be easily punctured, chipped or broken during the shipment. So the insulated box must be placed in a rugged outer container. Usually this is a corrugated cardboard box that will protect the Styrofoam® or other insulation from damage. Like bags and Styrofoam® boxes, outer cardboard boxes specifically designed for shipping fish are available from several Internet sources. The inner, insulated box should fit snuggly inside the outer box to give the best protection possible. A good quality packing tape should be used to seal the outer box.

Figure 2. Styrofoam® box in protective corrugated box.

Keeping the fish alive

Once fish are sealed in the bags and boxes, they must have everything needed to survive until they reach their final destination, which can be days later. The key to success is to protect fish against the deteriorating conditions. Some practices, like adding pure oxygen gas to the bags, are based on sound science and reason; others, like adding antibiotics to the water, may do more harm than good. Seek the advice of experienced shippers or a local Extension specialist when considering shipping practices you are unfamiliar with.

Oxygen

Fish need oxygen to survive and oxygen is actually hard to dissolve in water. During shipping, it is easy for the fish to consume more oxygen than is being replenished by diffusion unless you use a concentrated source and provide enough to last for the duration of the shipment. The bag should contain no less than half its total volume in oxygen, and many shippers seal their bags with at least two-thirds oxygen.

Compressed cylinders of oxygen can be rented or purchased from commercial sources. A regulator controls the flow of oxygen out of the cylinder and through a hose and valve to fill the individual bags. A standard “trigger” valve is the most commonly used, but for operations with a large daily volume a foot-operated valve may be more ergonomic.

Heat/cold packs

Temperature must be controlled during shipment, especially during extreme weather conditions or if the shipment will have a long layover at an airport where the boxes may be exposed to the weather for a considerable time. The use of insulated boxes may not be enough. Chemical packs, which are available for both heat and cold, usually require the user to mix the ingredients within a pouch. Depending on the type used, these packs can last no more than 8 hours or as long as 100 hours. Some heat packs use potassium compounds that give off heat when exposed to oxygen. In a sealed box, these packs often stop working once the oxygen in the box is exhausted, so they may not last as long as the labels claim. The type, size and number of these packs to use depends on the size of the box, the duration of the shipment, and the conditions of the “weather” during shipment. The shipper should be careful not to use too many. Reusable ice packs that can be refrozen repeatedly are also used.

Whichever type is used, packs should be added to the box just before it is closed and sealed. Avoid putting the packs on the bottom of the box as the water will be directly affected (heated or cooled) if the bag sits directly on the heat/cold pack. Some shippers tape the packs to the underside of the lid, and others wrap them in newspaper to prevent direct contact with the water through the plastic bags.

Tranquilizers/sedatives

Use of chemical tranquilizers during shipment is sometimes warranted, especially for large species. Tranquilizers slow respiration and metabolism, thus decreasing the rate at which water quality deteriorates. Tranquilizers also prevent some physical damage to the fish and shipping container. In the United States only two chemicals are legally available for tranquilizing/sedating fish.

Metomodate, sold as Aquacalm®, is allowed only for ornamental and aquarium species. This product was just recently made legal through the drug indexing section of the Minor Use for Minor Species Act (MUMS). Dosage ranges from 1 to 10 mg/L, depending on the species and duration of the treatment.

MS222, or Tricaine®, is also approved for use with finfish during transport, but is typically used for short periods. Dosage ranges from 5 mg/L to 50 mg/L, depending on the species and duration of the shipment.

There is some species data for both Metomodate and MS222. Be very careful when using these products with species for which there is no data. Before using these or any other products, read the entire label and seek the advice of an aquaculture Extension specialist if you are still unsure.

pH Buffers

During shipment, carbon dioxide levels increase in the bags, which causes a drop in pH. The extent of this drop in pH depends on the amount of carbon dioxide produced and the buffering capacity of the water. The buffering capacity of water is often described by the term "alkalinity," which is a measure of the water's ability to neutralize acids. If shipping water has low alkalinity, dissolved carbon dioxide can cause significant drops in the pH, so buffering agents may need to be added.

The most common buffers for adding alkalinity contain the weak bases bicarbonate (from sodium bicarbonate, also called baking soda) or carbonate (from calcium carbonate, also called limestone). Either of these can safely be added to shipping water. While small buffering packs can be added to each bag, it is less expensive and more effective to treat the water before shipment. Water for shipping fish should have a total alkalinity of at least 100 mg/L expressed as an equivalent of calcium carbonate.

Non-carbonate buffers are also available to increase the water's acid neutralizing capacity. The most common is called "tris" or "THAM," which are short names for tris(hydroxymethyl)aminomethane. Tris is an organic compound that buffers water at a pH of 7 to 8.5. It can be used at 2 to 4 g/L and can be purchased in prepackaged buffer packs to add directly to the water in the bags. Tris is best used when a large number of fish need to be shipped in a small volume of water and excess carbon dioxide is a concern. It will interfere with the effectiveness of some ammonia removal products.

Zeolite

Zeolites are common clay-like minerals that can adsorb positively charged ions (cations) from water. One type of zeolite, clinoptilolite, has a unique crystalline structure that adsorbs ammonium ions. Zeolite is much more effective in removing ammonium ions from freshwater than from seawater, as other cations in the seawater compete with the ammonium ion for adsorption. Zeolite specifically selected for aquaculture purposes is available from several sources. Zeolite should be used at a rate of 15 to 20 grams/L (57 to75 grams/gallon) in shipping water. It should be thoroughly rinsed with freshwater before use; otherwise it will make the water in the bag turbid or cloudy. Most shippers put it in small mesh bags so it will not be loose in the bottom of the fish bag. This makes it much more convenient at the receiving end of the shipment, as the recipient does not have to separate the loose granules from the water.

Figure 3. Zeolite.

Ammonia removal

There are several products that claim to chemically bind with, or "remove," ammonia from water. Some do not list their active ingredients, even on the required Material Safety Data Sheets (MSDS), so it is impossible to make any kind of recommendation on their use or efficacy. Active ingredients that are listed on other products, their efficacy, and their effect on shipping water, are as follows:

Sodium hydroxymethanesulfonate. In water, the sodium separates from this molecule, allowing the active ingredient hydroxymethanesulfonate to bind with ammonia in the water. The resulting by-products are water and sodium. This reaction takes place over a wide pH range but works best when pH is above 7.0 as there is more ammonia present in the non-ionized form.

Hydrosulfite and sodium bisulfate. The sulfite/sulfate portion of these molecules can bind with ammonia in water and reduce its toxicity. However, they also behave as acids in water and can lower the pH significantly.

Aliphatic amine salts. This is a large group of chemicals so it is difficult to make recommendations on their use, efficacy, or effect on other water quality parameters. None of the commercial products reviewed for this publication listed the specific amine salts used.

Salts

Osmoregulation is the continuous process by which fish maintain a balance between the salts inside their bodies and the salts in the surrounding water. In freshwater fish there is a higher concentration of salts in the body fluids than in the surrounding water. The body fluids of saltwater fish are more dilute than the surrounding water. Osmoregulation is an energy-consuming process in fish and when the balance is disturbed, fish will be stressed.

Fish are handled a lot as they are counted, sorted and moved from one place to another with nets, buckets, bags, etc. This handling can damage the slime coat, skin and other external barriers that are needed to maintain the osmoregulatory balance between inside and outside conditions. Damage to this barrier can lead to further stress during shipment.

Reducing the difference between internal and external concentrations of salts can reduce the energy expended in osmoregulation and reduce stress. Adding salt to the shipping water for freshwater fish relieves some of the osmoregulatory stress. Likewise, lowering the salinity of shipping water for marine fish will create a closer balance between the inside and outside concentration of salts. A difference as small as 0.5 to 3.0 parts per thousand will help during shipping. For freshwater shipments, use 2 to 11 grams/L (7 to 43 grams/gallon) of simple, coarse salt (i.e., sodium chloride, "rock salt").

Salts treated with anti-caking agents, such a nitroprusside, should not be used because there is evidence that they may be toxic to some fish. Other salts, especially calcium chloride (used primarily to melt snow and ice), have additives that accelerate their melting and should also be avoided. Salt for human consumption often contains iodine and cannot be used with fish, as it is extremely toxic.

Some species of fish show no apparent problems if the salinity is changed quickly by as much as 3 ppt, so salt is often added directly to the shipping water. However, some experts recommend slowly acclimatizing all fish to changes in salinity over a period of several days before shipping, and then again at the receiving end.

Antibiotics

Antibiotics should not be used in shipping water. Not only is this a non-labeled use, but there is also little evidence to support any benefits. The short-term use of antibiotics in fish can cause some bacterial strains to become resistant to antibiotics, and it is rare that the treatment will be continued for the required length of time after the fish reach their destination. If a bacterial disease is suspected, fish should be treated before shipment (see the following section on prophylaxis) or not shipped at all.

"Bacteriostatic Agents"

Some chemicals have been used historically in aquaculture as "bacteriostatic agents" to interfere with or even stop bacterial survival and reproduction in water. The most common of these associated with shipping fish are acriflavin and methylene blue. Neither of these products is labeled for aquaculture or for use in fish shipping water, and there is little to support their use in the literature.

Getting fish ready for the trip

Perhaps the most important part of shipping successfully is done well before fish are packed. It involves selecting the right fish for shipping and preparing them for the voyage. Only robust, healthy fish should be selected, with special attention to avoiding any diseased or damaged fish. Fish for shipment should be staged for at least 24 hours ahead of time in clean, well-aerated water with all food denied. Withholding food from the fish for at least 24 hours just before shipment allows them to purge their digestive tracts, which greatly reduces the buildup of wastes during shipping. It takes longer for larger fish to completely empty their guts. If the water is to be chilled for shipping, this should also be done gradually during the staging period. The fish should be housed in tanks where they can be harvested as simply and quickly as possible. Many shippers have the fish pre-counted and housed in individual tanks that correspond to the bag that they will be shipped in.

Prophylaxis

Prophylaxis is the treatment of a disease problem before it occurs. Because of the crowded and stressful conditions during shipping, parasites and diseases that the fishes' immune systems would normally counteract can often get an upper hand and can cause disease either during the shipment or, more commonly, shortly after arrival. Fish for shipping should be as free of parasites and bacterial disease as possible. With eggs or larval fish from a hatchery, this is usually dealt with already within the hatchery. But when fish are harvested from ponds, raceways or other grow-out tanks, parasites or opportunistic bacteria may be present so prophylactic treatment is recommended.

Some external parasites will be controlled with the changes in salinity used for reducing osmoregulatory stress, so no further treatment is required. However, many shippers will use a standard application of a broad spectrum anti-parasitic such as 12.5 to 25 ppm of formalin or 2 ppm of potassium permanganate to ensure that parasites will be removed from the fish before shipping. Potassium permanganate is an oxidizing agent also effective against external bacteria such as *Columnaris* sp. In conjunction with adjusting the salinity, either of these treatments will remove many common external parasites.

Fish should be visually inspected just before shipping to ensure that no disease or health issues have developed during the staging period.

Getting registered

Because of heightened national security, those who ship fish (or any cargo) via a commercial airline must become a "Known Shipper." Information about this requirement is available from the Transportation Security Agency (http://www.tsa.gov/what_we_do/layers/aircargo/database.shtm). Registration occurs with each airline or freight forwarding company you use. The requirements vary from simply providing proof of identification such as a valid driver's license to an on-site inspection by the airline's representative. Contact the airline you plan to use to determine what they require and how long it will take for you to get registered with them. If you are using multiple shipping companies or airlines, you must register and be approved by each one individually.

Scheduling the shipment

Getting fish from your facility to the buyer as quickly as possible is the key to success and requires good planning and scheduling. Commercial airlines make their schedules available online and in print. It is best to use the online schedules because they can change periodically, often before a new schedule can be printed.

Direct flights are always the best choice for obvious reasons. When a direct flight is not available, it is important to select the most direct route possible, with the shortest delay during layovers and transfers. Depending on the airline, you should allow for at least 1 hour between connecting flights to ensure that the boxes make it from one plane to another. Look for flights that have additional connections after the one you have scheduled. Then, if your first flight is delayed, your shipment might make the next scheduled flight. Having a shipment get stuck during a connecting flight is often disastrous, especially during extreme weather. Selecting an early morning flight is often best, as this allows the person who is receiving the shipment a full day to deal with flight delays or cancellations. Be sure to check the weather conditions, including at any connecting airports. If you think there is a good chance that flights will be delayed or cancelled, it is always much safer to reschedule the shipment.

Another option is to use a direct shipping company. This is becoming more cost effective, depending upon the size and volume of shipments. The boxes are picked up at your location and a guaranteed delivery time can be arranged. This typically is more expensive than handling the shipment scheduling and delivery yourself, but it can save considerable time and other expenses such as driving to the airport.

Finally, communicate your plans to your customer as they develop. The best scheduling can be ruined if the customer does not pick up the shipment promptly.

Labeling the boxes

The outsides of the boxes should be clearly labeled as containing live fish—in bold, easy-to-read lettering. Other warnings such as "Keep Warm" or "Keep Cool" (depending on the type of fish and the weather), "This Side Up," and "Handle Gently" should also be prominent on the boxes. Many states and almost all foreign countries also require that the exterior of the box contain a label that states the number and species of fish contained in the shipment. For large shipments with a wide variety of species, a "master" list can be attached to one box in the shipment. However, labeling each individual box with its contents is a good practice because it allows the receiver of the shipment to easily sort the boxes when they arrive. In addition to common names, the labels should also include the genus and species, or scientific names.

Each box should be numbered (e.g., 1 of 4, 2 of 4, 3 of 4, etc.) so the shipment can be accounted for easily at all times. Each box should also include the name, address, phone number and other important contact information for both the shipper and the recipient.

All labeling should be done with water-resistant markers and labels.

Handling the boxes

While most shipping boxes can withstand fairly rough handling, the fish inside can not. Train yourself and your employees to be as gentle as possible while loading and unloading the boxes. Always try to avoid any sudden jolts and even loud noises. The shipping process is very stressful on fish. Keeping them as calm as possible will increase their survival and health. Most airlines do a good job of training their employees to handle live fish boxes with extra care as compared to ordinary freight. Boxes should be boldly labeled to encourage gentle handling.

Loading rates

Determining the number of fish you can safely put into a box is critical to successful shipping, but the number varies with the species of fish, their size, the external weather conditions, and how long the shipment will take.

On a per weight basis, larger fish use less oxygen and produce less nitrogenous waste (ammonia) than smaller fish, so you can get more "weight" of fish per box than with small fish. Of course, the opposite is true for the number of fish, so often shipments include the smallest fish possible. As aquaculture expands globally, more and more hatcheries are shipping newly hatched larval fish or very young fry to international destinations. Because cooler water holds more dissolved oxygen and slows the fishes' metabolism, it is intuitive that you can usually get more fish in a box if the water is cooled. Shipments that take hours can have a higher density than shipments that take days. Densities can also be increased by purging fish before packing them. There is evidence that using Aqua-calm® (Metomodate) allows for denser loading rates.

However, the actual weight of fish that can safely be shipped is dependent on too many factors to provide exact numbers here. In one study, the weights varied by more than a factor of 10, from 22 grams/L for neon tetras (*Paracheirodon innesi*, a small fish) to 272 grams/L for goldfish (*Carassius auratus*, a larger fish). Even these numbers should be used only as an illustration, as they do not take into account the variations in the actual size of the fish, the conditions, or the duration of the shipment.

The cost of shipping can be as much as or more than the cost of the fish in some cases, so getting as many fish as possible safely in the box is often the goal. The packing density for many fish species is often based on years of experience as opposed to replicated experimental data. For example, in the ornamental fish trade, where shipping has occurred for decades, there are standard numbers of a given fish, of a given size, that are commonly packed in a standard 20-inch x 20-inch x 10-inch box. The variations among individual shippers are surprisingly small. In the goldfish industry, "boxes" of goldfish are fairly standard as well, based on the size of the fish and the time of the year. Smaller fish shipped during the cooler months will have more fish/box than larger fish shipped in the summer months. These numbers are readily available by looking at wholesale price lists from various ornamental and goldfish suppliers. Other numbers can be taken from suppliers of bait and sportfish. The best advice is to start with numbers that have been successful for other shippers with the same or similar species, or seek the assistance of an aquaculture Extension specialist.

Paperwork and documents

Each airline has its own airway bill that must be completed prior to shipment. This document includes key information such as the name, address and contact information of the shipper and receiver, the number of boxes, the contents, and any other specific instructions. Once delivered to the airline, this airway bill can be used for precisely tracking the shipment during transit.

There are often other forms and documents that need to be included with a shipment. Always consult the receiver to be sure any necessary health certificates or other documents are prepared well in advance. Many states have specific laws concerning which aquatic species are allowed, and the paperwork attached to the shipment must include exact numbers and species shipped. The outbreak of Viral Hemorrhagic Septicemia (VHS) in the Great Lakes region and the subsequent emergency rules banning movement of fish across state lines in the region is a good example of how individual states and the U.S. government can regulate interstate shipments of fish. Check with the receiver and the receiving state's regulatory authority to be sure you have addressed all requirements for the species of fish you are shipping.

International shipments may be especially challenging in terms of getting the necessary paperwork and documentation completed, so careful research and planning are essential. While there are efforts to standardize these requirements for the global movement of aquatics, currently there is a lot of variation from one country to another as to what they require or allow. Farm-raised fish and shellfish are exempt from U.S. Fish and Wildlife Service (USFWS) export permit requirements, assuming they do not contain any species listed under the Convention on the International Trade of Endangered Species (CITES) and/or the Endangered Species Act (ESA). If you have any doubts, contact the USFWS before scheduling the shipment. If the shipment does need an export permit from the USFWS, it may take a week or more to complete the process and there are fees associated with the permit(s). In addition, the shipment will need to be inspected at the point of export, which will also require scheduling and payment of a fee. The USFWS has the authority to inspect any shipment containing live animals at the point of entry or exit from the U.S. Having the boxes labeled thoroughly will assist in this process if your shipment is selected for a random inspection.

Almost all international shipments of live fish will require a health certificate endorsed by the USDA Animal and Plant Inspection Service, Veterinary Services (APHIS/VS). If you are shipping fish to, or even through, a country belonging to the European Union, your facility must be registered with APHIS as an export facility, which requires an annual on-site inspection of your farm and/or shipping facility by a veterinary medical officer (VMO). Depending on the location of the nearest VMO, scheduling this inspection may take awhile. You must pay an hourly fee, including for travel time. Once you are registered, each individual shipment must be inspected by a USDA-accredited veterinarian who can issue a health certificate. Fees for this service vary with individual veterinarians. After the veterinarian signs the health certificate, it must then be endorsed by the USDA VMO, a step that may take days.

For some species this health inspection involves a simple visual assessment to ensure that the fish are healthy. For others it may require certification that the fish are free of specific pathogens. It can take days or even months to get the final results, and there are diagnostic laboratory fees associated with the necessary procedures. If the certificate needs to certify your facility as free of a specific disease, this usually entails 2 years of testing with negative results before such a statement can be issued. The pathogens of concern are typically listed as "reportable diseases" under the Office International de Epizootics (OIE), the international body that regulates animal disease. As aquaculture expands globally, the number of specific diseases included on this list is increasing, so it is critical to thoroughly research this aspect of shipping fish before scheduling anything else. Contact your aquaculture Extension specialist or the USDA VS office in your state for further information. Also make sure that the receiver has thoroughly checked with his or her country's officials concerning what documents and certificates must accompany the shipment at the port of entry. Be sure the receiver has made arrangements to have the shipment cleared at the airport in a timely manner. Because of concerns about the interstate and international movement of live aquatic organisms, it is not uncommon for a shipment of fish to be rejected at its destination because it does not have the proper paperwork and documentation. Unfortunately, this usually means the loss of the animals before they can be returned.

Working on the receiving end

Good shippers work with their customers to be sure the shipment arrives as scheduled and is handled properly once it arrives. Contact the customer at all key points of the process. Give the customer the airway bill numbers or tracking codes to help in locating a shipment if it gets delayed or misrouted. Changes in numbers or sizes that occur between ordering and packing also should be communicated to the receiver so that the proper tanks or ponds are available for unpacking the fish.

Once the fish arrive, they should be removed from the boxes as quickly as possible once they are properly acclimated to the receiving water. When opening the boxes, take into account that the fish have been in the dark throughout the shipment. Boxes should be opened slowly and in a dimly lit area whenever possible. The pH in the bags will often be much lower because carbon dioxide has built up during shipment. The ammonia levels may be elevated, the dissolved oxygen low, and the temperature different than that of the receiving water. Slowly add water from the receiving tanks to the bags and, if possible, float them in the receiving tanks to equalize the temperature before removing the fish from their bags. Be aware that increasing pH suddenly in a bag with a high ammonia concentration can lead to problems, so monitor fish throughout the process and consider using ammonia-binding agents. Good acclimation should take as long as 30 minutes so the fish can slowly adjust to their new conditions.

Summary

Shipping fish in boxes is a standard method of transporting fish and has allowed aquaculture products to be easily distributed on a global scale. Limiting factors are similar to those we find in fish husbandry and production—temperature, dissolved oxygen, pH, ammonia and carbon dioxide. The main difference between fish culture and shipping is that once the bag is sealed, you can't do anything to manage these factors until the bag is opened at the end of the shipment. Proper planning and attention to shipping water, fish, shipping containers and scheduling are essential to success.

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