The Use of Salt in Aquaculture[1]

Ruth Francis-Floyd[2]

Salt, also known as sodium chloride or NaCl, has many potential applications in fish production. It effectively controls some parasites, minimizes osmoregulatory stress during transport, and prevents methemoglobinemia (brown blood disease) in channel catfish. While the Food and Drug Administration (FDA) has not approved the use of salt in aquatic animals, FDA considers the use of salt in aquaculture to be of low regulatory priority. The agency does not regulate the use of salt to control salinity.

What is Salt?

Salt is the generic term applied to the ionic or mineral component of water. All water except distilled or deionized water contains some salt. Minerals found in water have many important physiologic functions in fish. For this reason, fish should never be placed in 100 percent distilled or deionized water.

Although seawater is composed of many different salts, sodium chloride is the predominant one. Marine animals must be maintained in a saltwater solution that contains the micronutrients found in natural seawater. A number of products containing these nutrients are commercially available. Since the micronutrients present in sea salt are not critical for the survival of freshwater fish, either noniodized table salt or rock salt (suitable for consumption by humans or livestock) may be used for salt "treatments" in these species.

Salt Concentration

The effects of salt on fish are determined both by salt concentration and duration of exposure. Seawater contains 3 percent salt by weight; this is equivalent to 30 parts per thousand (ppt) or 30,000 parts per million (ppm). Some parasitic infestations of freshwater fish may be effectively eliminated by dipping fish in a seawater solution for 30 seconds to 10 minutes, depending on the species. Weaker solutions containing 0.5 to 1.0 percent salt may be used as a bath for several hours to eliminate some freshwater parasites. Concentrations of 0.1 to 0.3 percent may be used to enhance mucus production and osmoregulation in freshwater fish during handling and transport. Very weak salt treatments, measured in ppm, may be used to control methemoglobinemia in some freshwater fish species.

The Use of Salt as Parasiticide

Used in proper amounts, salt effectively controls protozoans on the gills and skin of fish. In many instances, however, too little salt is used, rendering the treatment ineffective. The duration of treatment is used to determine the appropriate salt concentration.

A 3 percent salt dip effectively removes protozoa from the skin, gills, and fins of freshwater fish; it also enhances mucus production. Depending on the species, fish can remain in a 3 percent salt solution from 30 seconds to 10 minutes. In general, fish should be left in the salt solution until they lose equilibrium and roll over. When this happens, the fish should be quickly removed from the salt solution and placed in clean, untreated water. Because some species (notably, some tetras) do not tolerate salt well, a bioassay (a test to determine safe concentration) should be conducted before large numbers of these fish are treated. A similar benefit may be obtained by dipping marine fish in fresh water. Marine protozoa burst when placed in fresh water, effectively removing them from the external surfaces of fish. Marine fish should be left in fresh water for no more than 10 minutes, then returned to a clean seawater environment.

If dipping is not feasible, freshwater fish may be placed in a brackish water (i.e., 1 percent salt) solution for 30 minutes up to several hours. This procedure produces the same effects as a saltwater dip; that is, it removes external parasites (protozoa) and enhances mucus production. It also benefits fish recovering from skin wounds.

Finally, a light solution of 0.01 to 0.2 percent salt may be used as a permanent treatment in recirculating systems. Such levels are quite effective in eliminating single-cell protozoans. Most fish can tolerate prolonged exposure to salt at these concentrations; however, tetras and fish that navigate by electrical field (e.g., elephant nose) should not be maintained in salt.

The Use of Salt to Transport or Handle Fish

When freshwater fish are transported and handled, they are forced to expend extra energy for osmoregulation (water balance) unless salt is added to the transport water. Freshwater fish tend to overhydrate when held in fresh water during shipping, due to the influx of water across the gills and into the bloodstream. To compensate for this water imbalance, fish pump excess water back across their gills. Increasing the salt concentration of the transport water inhibits this process, making depletion of energy reserves less likely. Salt may be added to the transport water to increase salinity from 0.1 to 0.3 percent (1,000 to 3,000 ppm, or 3.8 to 11.4 g/gal), minimizing the osmoregulatory stress on fish during shipment.

If fish are being transported from one site to another -- for example, from a pond to smaller tanks or vats within a building -- salt may be added to the receiving water. An easy way to accomplish this is to add a small amount of water to the receiving tank, then add salt to create a 3 percent solution (30 ppt or 30,000 ppm); when fish are added to the tank, it should be filled with water. Short-term exposure to a high concentration of salt produces an anti-parasitic effect; longer exposure to a lower concentration of salt helps to stabilize osmoregulation and increase production of the mucus covering the skin, which may have become damaged during handling.

The Use of Salt to Prevent and Treat Brown Disease

Freshwater fish, particularly channel catfish, are susceptible to brown blood disease, which is caused by an accumulation of nitrite ($N0_2$) in the water. Although most studies conducted on brown blood disease have used channel catfish as a model, many other freshwater species are also susceptible to the condition. A detailed discussion of nitrite toxicity is provided in a separate IFAS publication. Following is a brief review of the use of salt to prevent and treat brown blood disease.

In freshwater systems, nitrite toxicity is directly related to chloride (Cl^-) concentration, since nitrite ($N0_2^-$) and chloride (Cl^-) particles compete for space to cross the gills and enter the bloodstream (see Figure 1). As chloride concentration in the water increases, nitrite's ability to enter the bloodstream decreases.

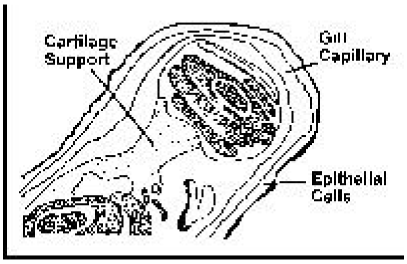

Figure 1.

The critical component in brown blood disease is the chloride (Cl^-) portion of the salt molecule (NaCl). For this reason, a test to measure chloride concentration (ppm) should be used rather than a test that uses a hydrometer or refractometer to measure salinity.

A minimum chloride concentration of 20 ppm is recommended to prevent nitrite toxicity among channel catfish in ponds. Most ponds are supplied with water containing at least 20 ppm Cl^-; however, salt should be added to ponds containing less than 20 ppm Cl^- to increase the chloride concentration to the desired level (see Box 1). For each acre-foot of water in the pond (1 surface acre, 1 foot deep = 43,560 ft^3), 4.5 pounds of salt adds 1 ppm chloride.

Box 1. Using Salt to Prevent Brown Blood Disease

Check chloride concentration in pond. If <20ppm, add salt as shown below.

Determine concentration of chloride [(Cl)] needed: 20 - [Cl^-] = [Cl^-] needed

Determine volume of pond in acre-feet (1 ac-ft = 43,560 ft^3).

For each ppm Cl^- needed, add 4.5 lb salt per acre-foot of water.

Example:

A fish pond has a natural chloride concentration [Cl^-] of 10 ppm.

Chlorine needed = 20 -10 = 10 ppm.

To determine volume, measure the pond. It is 100' x 200' x 6' deep = 120,000 ft^3.120,000 ft^3 / 43,560 ft^3/ac-ft = 2.75 ac-ft.

Amount of salt to add is:= [Cl^- needed] x Vol (ac-ft) x 4.5= 10 x 2.75 x 4.5= 124 lb of salt needed.

Example 1. Salt should be added to a fish pond containing less than 20 ppm chloride.

Salt may be used to minimize mortality and facilitate recovery of fish that develop brown blood disease. For every ppm of nitrite present, 6 ppm chloride should be used to control the disease. As described earlier, the producer must determine the required chloride concentration, adding 4.5 pounds of salt per acre-foot of water for each ppm Cl^- needed (see Box 2).

Box 2. Using Salt to Control Brown Blood Disease

Measure nitrite concentration ([NO_2^-]).

Measure chloride concentration [(Cl^-)].

Determine chloride concentration necessary to meet the recommendation of 6 parts chloride to each part nitrite: 6 x [NO_2^-] - [Cl^-] = chloride needed.

Determine volume of pond in acre-feet (1 ac-ft = 43,560 ft^3).

Add 4.5 lb salt per acre-foot for each ppm chloride needed.

Example:

[NO_2^-] = 10 ppm.

[Cl^-] = 20 ppm.

[Cl^-] needed = 6 x 10 - 20 = 40 ppm.

Pond is 100' x 200' x 6' = 120,000 ft^3.120,000 ft^3 / 43,560 ft^3/ac-ft = 2.75 ac-ft.

Amount of salt to add is:= [Cl^- needed] x Vol (ac-ft) x 4.5= 40 x 2.75 x 4.5= 495 lb of salt needed.

Example 2. To control mortality from brown blood disease, increase chloride concentration to 6 times that of nitrite. Add salt to increase chloride level.

Summary

Salt has many uses in modern aquaculture. Although FDA has not approved the use of salt as a "drug" to treat fish, the agency has designated salt as a compound of "low regulatory priority." Salt is inexpensive, readily available, and, when properly administered, safe for use in freshwater fish. Therapeutic uses for salt include parasite control, osmoregulatory stabilization, mucus production, and alleviation of methemoglobinemia in freshwater fish. Salt concentration should be based on intended use, duration of exposure, and tolerance of the species to be treated.

[1] This document is Fact Sheet VM 86, one of a series of the Department of Large Animal Clinical Sciences, UF College of Veterinary Medicine. Reviewed November 1995.

[2] Ruth Francis-Floyd, professor and UF/IFAS Extension veterinarian, UF College of Veterinary Medicine and UF/IFAS School of Forest Fisheries and Geomatics Sciences, Program in Fisheries and Aquatic Sciences; UF/IFAS Extension, Gainesville, FL 32611.