

## Maintenance of Water Quality for Healthy Fish

As with any aquarium (small home aquarium or large public aquarium) or pond (indoor or outdoor), a number of water quality parameters must be addressed. Each system in the public aquarium or facility with multiple ponds must be evaluated as a separate system independent of the others. Each of the exhibits or ponds would either have its own filtration system or share one with a few of the others that have the same requirements. Water quality maintenance involves the following parameters:

### Temperature

Maintenance of fish in their optimum temperature range is important in keeping them healthy. Tropical species typically require water temperatures that range from 75 to 85° F. The cold-water species require temperatures below 50° F. Therefore, to maintain the desired temperature for each system, either a chiller or heater of sufficient size is needed. Extremes in temperature should be avoided (a rate change greater than 2° C increase or 1° C decrease in a 24 hour period could affect the health of tropical fish). When building a new large public aquarium exhibit that requires cold water, chiller units must be designed into the filtration component. Sometimes the capacity of chillers does not meet the demands of the aquarium. Fish exposed to temperatures slightly out of their optimum temperature range may suffer from diseases (typically infectious diseases) associated with immunosuppression.

### Water hardness

Water hardness refers to the concentration of mineral ions in water predominated by calcium and magnesium. It is expressed in terms of calcium carbonate ( $\text{CaCO}_3$ ). One degree of hardness equals 17ppm  $\text{CaCO}_3$ . Soft water refers to water with 0-75ppm  $\text{CaCO}_3$  and has the lowest buffering capacity. Moderately hard water has 75-150ppm  $\text{CaCO}_3$ . Hard water has 150-300ppm  $\text{CaCO}_3$  and very hard water had a concentration of  $\text{CaCO}_3$  greater than 300ppm, which has the highest buffering capacity.

### pH

The pH of a freshwater aquarium system should range between 6.8 and 7.8, whereas, a marine aquarium should range between 7.8 and 8.3. It should be noted that an alkaline pH favors ammonia toxicity in a system having issues with increased ammonia levels. Also, an acid pH decreases oxidation of  $\text{NH}_3$  by bacteria and a pH of 4 and 5 will damage gills. New aquariums and ponds may demonstrate challenges in the adjustment of the pH because of chemicals leaching out of the new construction. Typically, the new public aquariums and ponds that are made out of concrete tend to be more alkaline requiring the addition of acid to keep the pH within normal range for the fish.

### Alkalinity and buffering capacity

Alkalinity refers to the concentration of basic substances, i.e. bicarbonate, carbonate and hydroxide ion in solution. It is expressed as ppm equivalents of carbonate; therefore, in general, total hardness measurements will be close to measurements of total alkalinity because Ca and Mg are generally associated with carbonate. Water with a high alkalinity is more strongly buffered than water with a low alkalinity. In a closed aquatic system, the pH decreases because of increase

hydrogen ions from respiratory processes and a pH "crash" (pH <4) occurs in soft water when all the buffering capacity is utilized. If a pH crash occurs, then a portion of the water should be changed and a commercially available buffer, such as dolomitic limestone, coral gravel, or oyster shell, should be added.

## Chlorine

Chlorine is used in municipal water supplies (usually 0.2-0.7 ppm total chlorine) to destroy pathogenic microorganisms. Chlorine, hypochlorous acid, and hypochlorite ion damage fish gills. They also combine with nitrogenous organic compounds to form chloramines, which are also toxic to fish. Total chlorine values refer to the free chlorine and chloramines concentrations in water. Chlorine can be removed from water by aeration or the addition of 1% sodium thiosulfate (usually 1 drop per gallon of water). Sodium thiosulfate neutralizes chloramines; however, it releases ammonia, which is toxic to fish. Ammonia is oxidized quickly by nitrifying bacteria in established aquariums or ammonia-absorbing clays (zeolites) can also be used. A lower pH (6-7) will also help to reduce toxic ammonia levels. Marine systems having a pH of 7.8-8.3 will potentially have higher toxic levels of ammonia when chloramine is treated with sodium thiosulfate releasing ammonia. The ammonia-absorbing clays are ineffective in salt water; therefore the chlorine and ammonia should be removed from the freshwater used to make up the marine water prior to mixing marine salts.

## Salinity

Salinity refers to the total concentration of all ions in water determined by electrical conductivity, chlorinity, chlorosity, or density of a water sample. The normal salinity for seawater is 35 ppt. Marine fish are hypoosmoregulatory, unlike freshwater fish, and osmoregulate by constantly drinking water. Chloride cells in the gills and mucus cells in the skin excrete the excess salt. Marine fish excrete concentrated urine in small volumes. Freshwater fish are hyperosmoregulatory, do not drink water, and excrete dilute urine in large volumes.

## Dissolved oxygen (DO)

Dissolved oxygen is measured using electronic meters. A DO of 5 ppm is adequate for tropical fish. Marine systems should have DO of 5.5 to saturation (6.8 is approaching saturation for salt water). The DO decreases as temperature and salinity increase.

## Ammonia, Nitrite, and Nitrate or the Nitrogen cycle and nitrification:

1. Excess food, feces, plant debris, and expired  $\text{NH}_4$  from the gills produce ammonia.
2. Ammonia is converted to nitrite by bacterial (*Nitrosomonas*) decomposition.
3. Nitrite is converted to nitrate by bacterial (*Nitrobacter*) decomposition.
4. Bacteria, algae, and higher plants utilize nitrate as a nutrient
5. Ammonia and nitrite are toxic to fish.

The new tank syndrome, "run-in period," or "conditioning period" refers to the period without the initial seeding of a new aquarium with nitrifying bacteria. In a closed aquatic system where fish have been added there is a period where ammonia and nitrites are elevated until nitrifying bacteria become established to remove these toxins. As a result, fish will begin to die of ammonia and nitrite toxicity (nitrites form methemoglobin from hemoglobin resulting in hypoxia) in a few days (i.e. 4-7 days) following the establishment of the new aquarium. This can be avoided by conditioning the tank with nitrifying bacteria (i.e. add 20% or greater gravel from an established aquarium or organic soil) and feeding the system with ammonia salts or urea (10ppm). Frequent 50% or greater water changes (twice weekly) may be required until the ammonia and nitrites are below toxic levels. One should avoid overstocking and feeding. Begin stocking with a few hardy fish

for the first two months, and then add fish slowly over time until the capacity of the system has been reached.

Treatment of an aquatic system for ammonia toxicity (>0.05ppm) involves:

1. Water changes and addition of conditioned gravel or foam filter from an established system
2. Decreasing the pH to near 7, if the pH is above 7 to convert ammonia to nontoxic ammonium.
3. Ammonia absorbers (zeolites) can be used, however they do not remove nitrites and do not work in marine systems.

Treatment of an aquatic system for nitrite toxicity (>0.1ppm) involves:

1. Water changes or removal of the fish to a healthier system will provide immediate treatment for nitrite toxicity.
2. Addition of gravel or foam filter from an established aquarium.
3. Increasing the salinity to 100 ppm (7 teaspoons table salt to 10 gallons) will prevent nitrite uptake in freshwater fish because chloride ion competes with nitrites for uptake.

Quarantine is essential in the prevention of disease outbreaks in closed aquatic systems. It is rarely performed in home aquariums, but highly advisable. Fish should be housed in a separate quarantine tank with its own water supply, filtration, nets, etc. for a minimum of 14 days for disease surveillance. During this period, fish may be treated for pathogens (i.e. parasites) as a precaution.