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WATER QUALITY AND THE MARINE AQUARIUM

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Within the marine aquarium, the tropical fish hobbyist attempts to simulate the stable yet dynamic marine environment. It is a difficult task because marine environments are in general considerably more stable than freshwater environments, and consequently marine inhabitants are far less tolerant of fluctuations in water quality than are freshwater inhabitants. Captive marine fish are in constant, intimate contact with an aquarium system's water and are dependent upon an appropriate, constant water chemistry to maintain internal homeostasis. Even small changes in water chemistry can stress marine fish and initiate disease outbreaks in marine aquaria. Marine aquarists should routinely monitor water quality and make appropriate adjustments before environmental stress occurs.

WATER SOURCES

Both natural and artificial seawater may be successfully utilized in marine aquaria, and both have advantages and disadvantages. The composition of natural seawater has been described (Harvey, 1963), as have formulas for artificial sea salt mixtures (Spotte, 1970).

Aquarists must generally live near a coast to have access to natural seawater. Natural seawater should preferably be collected through a deep subsand filtration unit that filters out most impurities and living organisms or from deep reef or pelagic sources where pollution is minimal. Natural seawater is generally much cheaper than artificial sea salt mixtures but may contain industrial and organic pollutants and living organisms that may parasitize fish and foul aquaria. Natural seawater should be allowed to settle in a dark container for several days and then passed through a mechanical filter containing activated charcoal to remove impurities and pollutants. Water quality parameters of each new batch of natural seawater should be tested to make sure the water is suitable for aquarium use.

Sea salt mixtures tend to be expensive but allow aquarists to maintain marine aquaria in any location. Good-quality, commercial, premixed salts produce seawater with standardized quality from batch to batch, but salt mixes may contain impurities and tend to be low in essential trace compounds, which may make them unsuitable for some applications. Artificial seawater is only as good as the freshwater used to prepare it. If tap water is used, aquarists should remove chlorine and chloramines with a commercial sodium thiosulfate solution and reduce copper levels with activated charcoal filtration. Artificial sea salts should dissolve readily and should not precipitate out of solution. Newly prepared artificial seawater should be allowed to equilibrate for several hours before use to allow pH to stabilize at 8.1 to 8.3.

IMPORTANT WATER QUALITY PARAMETERS

Marine aquarists should purchase water test kits to monitor aquarium water quality. Reasonably priced, accurate kits can be obtained from Hach Chemicals (Loveland, CO) and La Motte Chemicals (Chestertown, MD). The most important water quality parameters to monitor are listed in Table 1 with preferred ranges and trends. These parameters should be monitored at least weekly in well-established aquaria and daily in newly established aquaria and aquaria stressed by the addition of new fish, large water changes, or the addition of therapeutic agents.

Dissolved Oxygen

Aeration and gas exchange in marine aquaria are critical because seawater contains approximately 20% less dissolved oxygen than does freshwater at the same temperature because of seawater's high dissolved solids content (Curry, 1976). Dissolved oxygen can drop to dangerously low levels (<3.5 ppm) in marine aquaria with high salinity, high temperatures, dirty mechanical and biologic filters (high biologic oxygen demand), low lighting, and poor aeration. To maintain sufficient dissolved oxygen concentrations, aquarists should use aquariums with large surface areas for gas exchange, maintain low fish-to-water ratios, keep filter systems clean, employ vigorous aeration that moves 1.5 to 2.0 liters of air per liter of water each hour with small bubble diameter (Beleau, 1988), and use wet-to-dry trickle filter systems.

Salinity

Salinity is the measure of the total dissolved salts in seawater; it can be measured using a bulb hydrometer (specific gravity [S.G.]), temperature-corrected refractometer, or electrical conductivity. If a bulb hydrometer is used a nomogram should be used to correct for the effect of temperature on salinity (Oestmann, 1985). Because marine fish have adapted to a hyperosmotic environment, salinity is an important measure of the osmotic burden on marine fish. Deviations of salinity from the preferred range can have serious effects on the osmoregulation and homeostatic mechanisms of marine fish. Salinity tends to increase in marine aquaria due to evaporation of water and must be corrected for by the addition of freshwater.

Hydrogen Ion Concentration

Maintenance of proper hydrogen ion concentration (pH) in marine aquaria is essential for the health of marine fish. Values outside the preferred range can have detrimental effects on acid-base balance and osmoregulation in fish and lead to environmental stress and disease. Major factors affecting pH in marine aquaria are the amount of

*Table 1. Important Water Quality Parameters for the Marine Aquarium**

Parameter	Optimum	Preferred Range	Trends
Dissolved O_2	>6.0 ppm	5.5 ppm to saturation	—
pH	8.2	7.9 to 8.4	decrease
Specific gravity	1.024 at 26.7°C	1.020 to 1.026	increase
Salinity	32 ppt	28 to 36 ppt	increase
Alkalinity	4 mEq/L	2 to 6 mEq/L	decrease
Carbonate hardness	12 dKH	5 to 20 dKH	decrease
Phosphates	1.0 ppm	0.00 to 3.0 ppm	increase
Redox potential	325 to 350 mV	250 to 400 mV	decrease
Ammonia (NH_3)	<0.01 ppm	<0.05 ppm	increase
Nitrite (NO_2^-)	<0.1 ppm	<1.0 ppm	increase
Nitrate (NO_3^-)	<20 ppm	<50 ppm	increase
Copper	<0.05 ppm	0.13 to 0.2 ppm†	decrease

*Data from Moe, 1989; Spotte, 1979; and Stoskopf and Citino, 1987.
†Preferred therapeutic range only; otherwise concentration should be less than 0.05 ppm.

dissolved carbon dioxide, the concentrations of magnesium and calcium ions, and the accumulation of organic acids, phosphates, and nitrates. pH has a tendency to decrease in established marine aquaria. Key factors in the maintenance of proper pH levels include good aeration, effective biologic filtration, protein foam skimming, algae filtration, and regular partial water changes (Moe, 1989). Elevated carbon dioxide levels (with a consequent drop in pH) may result from lack of aeration and water movements, overstocking of fish, and bacterial overgrowths due to protein accumulation. Decomposition of organic wastes liberates organic acids that accumulate and bind bicarbonate and calcium carbonate, which in turn reduces the capacity of the seawater buffer system to maintain a high pH. Organic wastes also liberate phosphates during decomposition that combine with calcium and magnesium ions and effectively remove them from the seawater buffer system by precipitation, allowing pH to drop. Low pH in marine aquaria can be temporarily corrected by slow titration with sodium bicarbonate.

Alkalinity and Carbonate Hardness

The seawater buffer system is essential for maintaining normal pH in marine aquaria and for preventing devastating rapid pH swings. This complex buffer system has been well described (Gieskes, 1974; Spotte, 1970). Two parameters commonly used to monitor the buffering capacity of seawater are alkalinity and carbonate hardness. With constant addition of acidic waste products from fish and biologic filtration, buffering capacity of the seawater in an aquarium slowly diminishes over time, with a concomitant decrease in alkalinity and carbonate hardness. The marine aquarist can maintain the buffer system by filtration of organic matter and frequent detritus removal. Regeneration of the buffer system requires frequent partial water changes and addition of commercially available marine buffers.

Ammonia, Nitrite, and Nitrate

Establishment of nitrification in closed aquarium systems is essential for fish health. The nitrification process or nitrogen cycle is well described (Citino, 1989; Spotte, 1979) and prevents accumulation of toxic nitrogenous wastes. Monitoring the nitrogen cycle by determination of ammonia (NH_3), nitrite (NO_2^-), and nitrate (NO_3^-) concentrations is a valuable tool for assessing the status of biologic filtration in marine aquarium systems. NH_3 and NO_2^- are both very toxic to fish and are generally present at barely detectable levels in established marine aquaria, while NO_3^- is relatively nontoxic to fish and continually accumulates in closed aquarium systems. In newly established aquaria, NH_3 and NO_2^- levels rise due to insufficient colonization by nitrifying bacteria and often reach toxic concentrations, with fish mortality 2 to 4 weeks after addition of fish ("new tank syndrome"). NH_3 and NO_2^- levels also rise when biologic filtration is overwhelmed by overstocking and accumulation of organic wastes or is curtailed by agents that destroy nitrifying bacteria (i.e., erythromycin, new methylene blue). Aquarists can maintain low nitrogenous waste concentrations in marine aquaria by establishing and maintaining a suitable biofilter (i.e., trickle filter, fluidized filter bed, undergravel filter), keeping fish populations within biofilter capacity, adding new fish slowly, removing organic detritus and wastes by mechanical filtration and siphoning, and frequent partial water changes.

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