



A SPECIAL SECTION ON WATER RE-USE AND RECIRCULATION

NUTS & BOLTS

By STEPHEN PIGGOTT

Photos courtesy Dr. Leonard Obaldo, Oceanic Institute, Waimanalo, Hawaii.

Land-based Seawater Aquaculture Systems

The differences between freshwater and seawater hatcheries are like the differences between a station wagon and a minivan or between lager and ale, subtle yet distinct

With the push to diversify aquaculture opportunities and develop markets for high-value marine species, land-based seawater systems have become the focus of much research and development. The technologies and designs being developed for the seawater environment are largely adapted from freshwater systems. Therefore, the differences between freshwater and seawater hatcheries are like the differences between a station wagon and a minivan or between lager and ale, subtle yet distinct. The processes that add feed, oxygen and make-up water, and remove solid wastes and ammonia, are basically the same, but the salt water adds a twist to the design.

Corrosion problems

The most obvious difference between seawater and fresh water facilities lies in the materials used. Most metals will corrode. Even stainless steel, which is corrosion-resistant in fresh water, can corrode in seawater. Stainless steel and other corrosion-resistant metals resist corrosion by formation of an impenetrable oxide coating on the surface. However, in low-flow or low-oxygen conditions, corrosion pits can form. If the acidic corrosion products are not washed out, and oxygen is not carried in, this corrosion is accelerated. As this type of corrosion will commonly develop in seams and joints, it has been called crevice corrosion. Corrosion products of stainless steel can be toxic as they include chromium and nickel. Many facilities choose to use iron or mild steel products because, although the rust is unsightly, it is generally accepted to be non-toxic. The alternative seems to be to use titanium or plastics, which can be very expensive for precision parts.

Another type of corrosion that occurs is the galvanic reaction between different metals. In this type of reaction, a galvanic or "battery" cell forms which will result in the dissolution of the electro-negative material. If dif-



PRAqua-designed Land-based recirculating seawater facility for raising Amberjack at Oceanic Institute. The water treatment system is on the left.

ferent metals of any kind are used in seawater systems, it is important to provide an insulating material between them to minimize this type of corrosion. As a result, seawater system designs tend to rely much more on plastic and glass products. Similarly, PVC and HDPE are the materials of choice for piping. Some seawater facilities use titanium, fiberglass or plastic pumps to minimize the potential for corrosion. Alternatively, more care and maintenance must be devoted to ensuring that corrosion does not have a chance to develop and cause failures.

Water treatment

Beyond the material differences, there are slight differences between water treatment technologies employed in seawater and those in fresh water systems. pH has an important effect on many of these systems. The pH of seawater is normally between 7.9 and 8.3 while fresh water is closer to 7.0. Dissolved car-

bon dioxide is always in a state of equilibrium with the water. Depending on pH and alkalinity, some of the toxic CO₂ is converted to bicarbonate and hydrogen, which lowers the pH. In seawater, because of the initial high pH and alkalinity, more carbon dioxide can be converted with less of a pH change, as carbonate is changed to bicarbonate. As a result, stripping excess CO₂ from seawater systems appears to be much less important than from fresh water systems. However, CO₂ stripping may still be employed since it offers an economical source of oxygen.

In water, most ammonia is ionized into the essentially non-toxic form: NH₄⁺, but the percentage of ammonia that remains in the toxic state (un-ionized NH₃) is dependent on both the pH and the salinity of the water. The fraction of un-ionized ammonia decreases as salinity increases, and increases as pH increases. In a fresh water system at 10°C, pH of 7 and salinity at

0‰, 0.19% of the TAN will be in the toxic un-ionized form. In a seawater system at 10°C, pH 8.3, and salinity at 35‰, 1.9% of the TAN will be in the toxic un-ionized form...a ten-fold difference!

Alternatively, nitrite can be a problem in fresh water systems. The solution in most facilities is to add salt! Raising chloride concentrations to 50 mg/l has been found to raise the tolerance of salmonids to nitrite by a factor of 50. Some species have been found to tolerate concentrations as high as 200 mg/l. As a result, nitrite toxicity is typically far less of a concern in saltwater.

Oxygen concerns

The solubility of oxygen is slightly reduced by increased salinity. Therefore, to support the same biomass, water exchange rates, or the percentage of oxygen super-saturation in the supply water may need to be higher.

The formation of micro-bubbles is much easier in seawater systems than in fresh water.



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Large PVC gate valve used in Oceanic Institute's recirculating seawater facility. Plastic is the material of choice for many seawater systems.

This has both positive and negative consequences. Foam fractionation (protein skimming) or dissolved air flotation (DAF) units operate by forming fine bubbles. Small particles will attach to the surface of the tiny bubbles, which float to the surface where they can be skimmed off, taking the fine particles with them. Therefore, protein-skimming equipment can be used in seawater to efficiently remove these otherwise hard to remove particles, whereas most fresh water systems rely on flushing to remove these fine materials.

On the other hand, since forming micro-bubbles is so easy, foam can be produced in undesirable locations. For instance, foam may be created in an aeration tower by the rain of droplets onto the water surface. This foam carried into pipes and pumps can result in air locks, which require relatively massive air relief systems.

Ozone options

The oxidizing power of ozone gas in a disinfection system is increased at the higher pH normally found in seawater. However, the addition of ozone to seawater may produce long-lived toxic byproducts including bromates, bromides and bromous acid. Ozone has been used successfully in seawater systems to rear species that are tolerant of these compounds, but it is the owner/operator's responsibility to determine if the cultivated species are sensitive.

Therefore, like the autos that will all transport people in their own way, or the alcohols that will intoxicate, the systems and equipment that are used in land-based seawater culture facilities are similar to those employed in fresh water facilities, but with special modifications incorporated to reflect the subtle differences that the water has on the system design.

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