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Chapter 27

80,000 liters of a live coral reef display - 7 years and counting

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ABSTRACT
Designing, building and maintaining an 80,000 liter reef display at Atlantis Marine World has proven to be a quite challenge, especially since the largest public aquarium reef display in the USA prior to this tank was a 5,300 liter I set up at the New York Aquarium in Brooklyn, New York USA in 1993. The initial design of the Atlantis display to provide all aspects of necessary life support worked well, and constant changes and improvements are ongoing as the reef tank continues to mature over the past 7 years.

INTRODUCTION

The reef tank here at Atlantis Marine World is 7 years old as of November, 2007. The history of this exhibit is difficult to discuss without reviewing some local reef keeping history. There was a time when reproducing *Aiptasia* anemones and growing some *Valonia* algae were considered special and *Goniopora* sp. coral was thought to be "easy to keep", since it lived longer than other corals. In reality, the *Goniopora* sp. just took longer to die than the other corals.

My first exposure to live corals was at the New York Aquarium in Coney Island, Brooklyn, New York in 1987, where I worked as an aquarist. At that time, there was one 340 L exhibit, but only a few corals survived while others faded away. I was intrigued to watch soft corals, such as star polyps, spread over the substrate and generate new polyps; to me this was simply amazing. However, as an admitted "coralaholic", I craved a bigger aquarium and set up a 680 L experimental reef tank. The first *Acropora* frag ever placed in a flower stem holder was inaugurated in this aquarium. I take great pleasure in seeing this technique used around the world.

A major leap forward for aquarists in the United States occurred when Alf Nilsen published a series of articles in U.S. magazines in 1990. Alf's amazing aquarium photographs of wonderful corals were inspiring, knowing that they were not staged. Reading words like "potassium iodide" and "strontium chloride" had me scrambling to the lab and dusting off old brown bottles to find these chemicals. At that time, it was a great benefit to be a professional aquarist as well as a hobbyist. We owe a lot to the reef hobbyists, like Alf, who led the way showing professionals how to do it right. Among the professionals, Dr. Bruce Carlson was one of the people who was instrumental in bringing the hobbyists and aquarists together for the benefit of all.

In 1993, the New York Aquarium set up a 5,300 L, which was a major undertaking. The 'coralaholic' craving is a strong, and an even larger tank was required to fill this need. By the year 2000, as co-founder of the Atlantis Marine World Aquarium on Long Island, New York, the plans *somehow* included an 80,000 L reef exhibit.

THE TANK AND REEF STRUCTURE

Even though Atlantis Marine World is a public aquarium, the reef exhibit is considered my own "do it yourself" project. We designed, fabricated, and built everything in house so there is a great sense of ownership, much like a hobbyist feels about his or her own aquarium. This exhibit is 9 m long x 4.25 m wide x 2 m deep. The rest of this article will describe in detail how this exhibit was constructed and our experiences managing it over the past seven years.

The tank is poured concrete with walls 30 cm thick reinforced with epoxy coated rebar. The two acrylic windows measure 3 m x 1.8 m x 9 cm thick. The interior is sealed with a polyurea lining, much like the sealant used as bed liners for pick up trucks. The base rock consists of ~14,000 kg of quarried Wisconsin limestone (www1), estimated at 300 million years old. It is very dense limestone and required up to eight people to move some of the slabs. All this rock was secured in place with natural lock-and-keys and no cement was used.

An additional 4,500 kg of live rock was placed on top of the limestone base rock. The live rock was a special order for large pieces, some weighing as much as 25 kg. The live rock was held off site for several months to cure, so no major curing took place within the tank. Once the limestone base rock installation was completed, portions of the live rock was transported to the aquarium in a pick up truck. The live rock was placed around the tank to about 30 cm off the bottom. 30 cm of water was then added, and this was repeated until it was too deep to walk around. The remaining rock was placed using SCUBA. The rockwork does not extend to the back wall, and the lighting was designed so that it does not emphasize the back wall, so that it fades from view making the tank appear much wider than it actually is. Originally the sidewalls were exposed, but eventually vertical walls of live rock were attached using a hammer drill and 2 cm diameter fiberglass rod.

The first coral and other invertebrates were placed in the tank after the rocks were installed, but this was not rushed. The first fish introduced to the exhibit were mostly tangs to help control algae. No algae blooms occurred, most likely due to curing the live rock prior to installing it in the tank.

LIGHTING AND FILTRATION

The lighting has evolved to include twelve 1000 W Daylight metal halides (Venture Cool Deluxe), eight Blue metal halide (Venture Color Series BDX), six 400 W 10,000 K metal halides, and one 400 W 20,000 K moonlight. There are eight translucent skylights that each measure one meter long and 15 cm wide that provide insignificant light for the corals. However, the do create a pleasing, subtle wake up period for the fish.

The protein skimmer is my own design and fabrication and is fusion-welded from standard polyethylene containers from Chemtainer (www2). The contact chamber measures 1.2 m diameter and 1.8 m tall, with the entire skimmer measuring just over 3 m. It uses a 3.7 kW pump to run a 2” Mazzei venturi and the total flow is about 48 $m^3.h^{-1}$. 1 $g.h^{-1}$ ozone from a Del EC4 ozone unit (www3) is injected into the protein skimmer. A modified ETSS 5000 protein skimmer (www4) with a one meter extension has also been added, which has 24 $m^3.h^{-1}$ going through it. The air intakes had to be modified to handle that much water flow.

Water flow in the tank is a great and a never ending challenge. A 3.7 kW pump (48 $m^3.h^{-1}$) powers a closed-loop system. Part of that water goes to a 1200 L Carlson Surge Device (CSD) which takes about 8 minutes to fill, and empties in 35 seconds. The closed loop also feeds three 3.8 cm eductors. The clown tangs (*Acanthurus lineatus*) love surfing in the outflows of these eductors. Total flow volume through the eductors is ~144 $m^3.h^{-1}$. Random flow is achieved by using five 1” SeaSwirls (www5) and a recently installed WavySea (www6). Other random flow is achieved by using a rotating device from the pool industry (Master Pools Turbo-Clean Actuator, produced by: Pentair Water).

Propellers are a very efficient way to move water, and an in-house prototype unit utilizes a 370 W DC motor and a 5” prop, and at full power it can move 120 $m^3.h^{-1}$, with an average flow rate of 60 $m^3.h^{-1}$. Also recently installed is a prop-driven prototype device that is a converted MagDrive 18 pump that moves an incredible amount of water. A floating Scotts Aerator 370 W prop unit (www7) is also used after hours to “storm” or stir up the tank several times/ week. This unit is so strong (a focused 120 $m^3.h^{-1}$), it can only be used for short periods of time. Additional water flow will be added over time, and it is extremely important to remember that what worked in the first few years, probably won’t work in the subsequent years. This is mostly due to the ever-increasing size of the coral colonies that disrupt the established water flow. As of November, 2007, total flow including all pumps, eductors, and prop units is 500 $m^3.h^{-1}$ or ~6x per hour total tank volume.

Mechanical filtration is handled by two high rate sand filters, filled with silica sand with a combined flow rate of 50 $m^3.h^{-1}$. As the biomass of the fish and corals increases, additional sand filters will be added. Detritus accumulation has been a continuing problem in the tank and more mechanical filtration should be minimize the problem.

WATER PARAMETERS, WATER QUALITY MANAGEMENT AND DOSING

Natural sea water is used from a local body of water called Shinnecock Inlet which opens to the Atlantic Ocean. The water is trucked to Atlantis Marine World and held in a 76,000 L holding tank and used in all of the marine tanks. Water changes are generally 5-10 % per week. The natural sea water is less then optimum for reef keeping due to its low pH, alkalinity, and calcium concentrations, but the normal daily dosing on the reef tank soon brings the water to acceptable levels (see below for specifications). Water temperature is generally between 23 to 27°C, and is maintained by a plate and frame heat exchanger which is connected to a central Geotherm cooling loop.

There is one 570 L trough attached to the tank that has some macro algae (*Chaetomorpha*), so 30 ml of iron is dosed 2-3x per week. The iron dosing helps the algae grow, as well as may help the zooxanthallae. The stock solution is the one recommended by Randy Holmes Farley (www8).

Calcium demands are handled by in-house custom built calcium reactors. The pH in the reactors is kept between 6.3 and 6.5 utilizing a PinPoint pH controller. On average, 200 kg of reactor media is replaced every 4 months. Also included in the media is about 5 % dolomite to help maintain a magnesium level of 1100-1200 mg $Mg^{2+}.L^{-1}$. Additionally, up to 190 $L.d^{-1}$ of milky white suspended CaO solution is dosed. This stock solution is made from 5.5 kg of CaO mixed with 190 L of RO water. The combination of both techniques maintains a calcium level of 390-420 mg $Ca^{2+}.L^{-1,}$ a pH of 8.3-8.45 and alkalinity of 2.9-3.6 $mEq.L^{-1}$

Other chemical additions include an average of 600 ml of a 20 % $SrCl_2$ solution every two weeks as well as 600 ml of a 1 % KI weekly as well, both of which are from ESV (www9).

All the water that goes through the calcium reactors then passes through a reverse flow custom made reactor filled with Rowaphos/Phosban to remove any phosphates released by the media in the calcium reactor.

Phosphate is a major concern with a large aquarium and while Phosban (www10) works well, the large volume of the display makes it impossible to use only this product for phosphate control. Water changes are a possible option, but even a small 20 % water change is still requires 16,000 L. Over the past two years, the display has been dosed with lanthanum chloride ($LaCl_3$) obtained from Vanson-Seaklear (www11). The dosing regiment is currently 300 ml diluted in 19 L of RO water, then slowly dripped over several hours into the sump which goes directly to the protein skimmer. This will reduce phosphate level an average of 0.10 mg $PO_4^{3-}.L^{-1}$ overnight. The target phosphate level for this tank is below 0.20 mg $PO_4^{3-}.L^{-1}$. If it rises higher, coral growth will decline and their colors will fade. When using $LaCl_3$ based products, they must be dosed with great care, but the regimen described here works well.

Anecdotally, we have made observations that suggest that Phosban, which is a granular ferric oxide compound (GFO) may remove harmful compounds that accumulate in reef tanks. Several years ago, many of the corals, anemones and other inverts appeared stressed even though the standard water quality parameters were normal. Phosban had just become available and we tried some on the aquarium. Within three days, the soft and stony corals, mushroom anemones, that were not extending were relaxed and showing normal polyp extension. The phosphate concentration had not changed, so we assume the Phosban removed some irritant that the protein skimming with ozone and carbon filtration could not remove. For that reason, GFO products are probably a benefit for reef keeping systems.

Nitrate concentration has remained below 10 mg $NO_3^-.L^{-1}$. Presumably, sufficient denitrification is occurring within the rock substrate to remove nitrate from the aquarium.

PHYSICAL MAINTENANCE

Most of the maintenance can be performed from walkways around the top of the exhibit using a 5 m cleaning pole and 3 m long grabbers (www12) but about every 5 days the tank is dove to inspect the corals, prune them, plant fragments and to remove stubborn algae from the windows. The SCUBA tank remains on the tank walkway and the diver uses a long regulator hose and extra weights and carefully walks around the tank underwater.

FISH

Initially, the exhibit focused more on the corals, but as time progressed, more emphasis was given to the fish. Courtship and spawning events have been observed with the hippo tangs (*Paracanthurus hepatus*), and yellow tangs (*Zebrasoma flavescens*), a variety of wrasses, including cleaner wrasse (*Labroides* sp.), genicanthus angelfish (*Genicanthus spp*), cardinal fishes, damselfishes and anemone fish (*Amphiprion* sp.) and anthias (*Pseudanthias* spp.). None of the eggs have been collected. However, engineer gobies (*Pholidichthys leucotaenia*) have spawned and the young have been removed from the tank and reared. After speaking with colleague Kevin Curlee about the spawning event, both he and Dr. Eugenie Clark visited Atlantis. Dr. Clark had been researching this species in the wild, and these spawning events provided valuable data. As of August 2006, eggs from the damselfish *Amblyglyphidodon aureus* have been removed a couple of nights before they were due to hatch. The eggs were then held in a remote glass tank, the fry hatched out and we have currently reared ~1000 young.

The growth of the small polyp stony corals has been explosive over the past two years, which has lead us to reconsider which species of fishes might be considered “reef safe”. Several of the fascinating orange spot filefish (*Oxymonocanthus longirostris*), have been introduced to the reef tank and two mated pairs have formed. They cruise the tank and graze constantly on the corals, but we have not observed any harm to the corals. These filefish feed on prepared foods too, but always return to graze on the corals. We have speculated that the constant pruning may actually stimulate coral growth.

The fishes are fed a diet of mysis shrimp, *Cyclops*, Aquatrol spirulina flake food, New Life Spectrum pellet foods (www13), sandeels, and on occasion frozen rotifers and spray dried phytoplankton. There are several feedings every day because of the many fishes, including potential coral-feeding species like emperor angelfish (*Pomacanthus imperator*), bluering annularis (*P. annularis*), majestic angelfish (*P. navarchus*), blueface angelfish (*P. xanthometopon*) and regal angelfish (*Pygoplites diacanthus*). Keeping these fishes well fed reduces the risk that they will damage the corals and other invertebrates. These fish do still nibble on some of the large polyp stony corals and some soft corals, but as long as they are well fed, they have not destroyed any coral colonies. These fishes would probably benefit from an aquarium at least 120 cm deeper to allow them more room for courtship and spawning.

CONCLUSION

Once a Coralaholic, always a Coralaholic. The reef tank is my baby and mistress in one. Reef keeping is a science coupled with art, and a reef aquarium is something that needs to be constantly designed for both form and function. The corals and fishes form a living palette of color to play with, and that palette is truly dynamic by nature. Being open to change and adaption is essential, often what worked the first few years may not work in the subsequent years. Reefkeeping is much like an intense chess match, where you must stay at least 20 moves ahead of your opponent just to stay in the game. Not to win, but to just hopefully stay in the game. So enjoy your reef aquarium, but don’t get too comfortable as your “opponent” is just waiting for you to make a wrong move. Stay ahead of your opponent and you both can stay in the game for many years to come.

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