Design and Testing of a Self-Contained, Wirelessly Monitored and Controlled, Automated LSS System for a 100 hour sealed Transport of Large Teleosts and Elasmobranchs

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Abstract

Historically, the long-distance transport of large teleost and elasmobranch specimens, weather newly collected or moved between collaborating facilities has always been problematic. Even when purged and/or sedated, the high metabolic demands of a large mass animal compounded by handling and transport stress often leads to the rapid deterioration of water quality during transport. The window for successful transport is exceedingly small and mortality/morbidity is an ever-present fear even under ideal conditions and schedules. The Walt Disney Animal Science and the Environment Water Sciences Department, in collaboration with Aquatic Equipment and Design Inc. (AED), and McDaniel Consulting, LLC (MDC) have devised a sophisticated, fully portable, battery powered, remotely monitored, animal transport life support system to greatly increase the margin of safety during transport and maintain exceptional water quality, even under the most challenging conditions with the most sensitive animals. The system actively monitors and controls flow in the transport container, controls temperature, captures suspended solids down to 5 microns, and using an innovative technology re-purposed from the pharmaceutical and semi-conductor industry, maintains dissolved gas balance without the use of atmospherically vented or forced draft packed column de-gassers/strippers.

Killing Three Birds with One "Green" Stone: Making a Hill-*William* Heat Exchanger

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Abstract

We all have a surplus of grand ideas but usually we find ourselves with a deficit of money to implement them. But when animal welfare is your priority, we need find a way to make things work. In this instance, we were able to solve three issues with one simplistic design. By using off the shelf materials, we were able to create a heat exchanger which solved our cooling needs in one 4,200 gallon saltwater system, our heating needs in another 6000 gallon freshwater system, and of course implementing the solutions without spending a lot of money. Additionally, we were able to eliminate the need to add any mechanical equipment or any additional energy demands to solve the problems.

9,000 Pounds of Acrylic and Water Suspended 15 feet in the air, Add Over 200 Fish and a Scissor Lift and You Get…….. Fish Globes!?

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Abstract

Long before the opening of the OdySea Aquarium in Scottsdale, Arizona the founder of the aquarium envisioned an exhibit seen nowhere else in the world. The "Aqualobby", as it is appropriately named, is home to nine acrylic globes suspended between ten and fifteen feet above aquarium guest. Approximately thirty fish call each of the globes home. From vision, to design, to construction, and daily care, this presentation will cover the initial LSS design of these systems and some of the challenges encountered with this industry first.

You Want Me to Build What, Where?!
The Challenges of Building a 12,000 Gallon Stingray Touch Tank 16 Miles from the Main Facility

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Abstract

The Florida Aquarium, Tampa Florida partnered with Tampa Electric Company (TECO) and their Manatee Viewing Center in Apollo Beach, Florida in 2016 to design, build, and run a 12,000-gallon stingray touch tank. The property on which the tank was to be built is in a flood plain 16 miles from our main facility. The design and build was done as a partnership between TECO, their contractors, and the Florida Aquarium life support and husbandry staff. Staffing changes after the initial design phase was completed and equipment was purchased created some challenges as construction was beginning. As permits were pulled and final prints drafted, changes had to be made and new equipment bought since the contractors had eliminated "unnecessary" components to force all of the purchased equipment into the proposed building footprint. Once over the initial hurtles, construction was completed and we opened the touch tank to the public. While we ended behind schedule, the time we took up front to make the needed changes ensured that the system ran as planned, maintenance was possible, and the public that came to see the stingrays where enthralled.

Foam Fractionator Level Control for Variable Supply Flow Applications

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Abstract

Foam Fractionators work best when receiving consistent source water. Unfortunately many applications have variable flow rates by virtue of their operation. Many Foam Fractionators are supplied post solids filtration creating either a diminishing flow over time or pulse flow depending on the equipment. During a recent habitat renovation we were tasked with adding filtration to a raw seawater source. The filtration needed to fit inside the old sumps. In this application the water source is from a shared seawater intake. The flow rate varies based on demand of other uses and the tide. First stage filtration is through a rotating drum screen filter. The drum filter also creates a pulse flow which is inherent in normal operation. Considering these factors it was decided to control the level of the foam fractionator through modulating the discharge flow rather than the supply. To achieve this, a butterfly valve with ozone resistant components was installed low on the discharge stack. The valve was equipped with a pneumatic actuator with position control. A pipe was installed low on the fractionator body and extended above the collection cup to act as a stilling well. A sonic level sensor was used to measure water depth and provide input to the pneumatic valve. The positioner was programmed with a user defined slope to tune the flow control to the specific installation. The resulting system provides accurate level control to within 0.5" within 20 seconds of flow variation.

Two Years Already? The Success and Challenge of the Detroit Zoological Society Polk Penguin Conservation Center

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Abstract

The Polk Penguin Conservation Center opened at the Detroit Zoo in April 2016. The habitat pool has a volume of 326,000 gallons of filtered freshwater with a maximum depth of 22 feet. Perlite media filters, ozone and biological filtration provide excellent water quality for the penguins and clarity for our guests. Habitat pool and air temperature are maintained at 42°F. Filtration is monitored continually and controlled at several points throughout the system. Establishing a life support system of this size and complexity can be very challenging, and a number of steps were taken to prepare the habitat for penguins. Since then, we have continued to make modifications and adjustments, to ensure that we continue to provide an ideal habitat for the penguins and an outstanding experience for our guests.

Preventing Jelly Jams: A case study in flow modifications for *Chrysaora pacifica* at National Aquarium

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Abstract

Gelatinous zooplankton are some of the most simplistic and mesmerizing animals commonly displayed in aquaria, yet the engineering required to house them is remarkably nuanced. With varying body types and modes of locomotion, flow requirements vary widely between species, as well as between developmental stages within the same species. Despite the simplicity of these animals, their behavior also plays an important role. To decrease the risk associated with the inherent dynamics of an existing stretch kreisel housing adult *Chrysaora pacifica* in the National Aquarium's Jellies Invasion gallery, a 2nd Hartford loop and 2 topside spray bars were installed. These simple modifications have resulted in fewer jelly jams due to a decrease in the necessary flow rate, an even split of head pressure on each kreisel screen, and the animals naturally positioning themselves farther away from the screens and in the viewing window. The longevity and wellbeing of the animals has increased, as has the percentage of jellies viewable to the public, while aquarist anxiety has markedly decreased. Inventory and animal health notes allowed for analysis of longevity and wellbeing, while viewability was analyzed from photo documentation. Aquarists' levels of concern were queried via an online survey. Similar LSS modifications have since been employed in 2 other kreisels, yielding similar results exhibiting *Aurelia aurita*, *Chrysaora colorata or C. chesapeakei*, thus demonstrating the plasticity in application for various Scyphozoans.

Lighting the Aquarium Experience: Exhibit Lighting Lessons Learned

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Abstract

Ripley Entertainment owns three world class aquariums; Ripley's Aquarium in Myrtle Beach, SC which opened in 1997; Ripley's Aquarium of the Smokies in Gatlinburg, TN which opened in 2000 and Ripley's Aquarium of Canada in Toronto, ON which opened in 2013. Our biggest challenge in each has been exhibit lighting. With each aquarium we have tried different approaches, Myrtle Beach did not work out, and Gatlinburg did not work out. We tried something different at the Aquarium in Toronto. After all was said and done we won some battles but suffered some defeats many lessons were learned along the way, lets discuss both the wins and losses to improve exhibit lighting in aquariums.

Total Gas Pressure Monitoring and Trends in Temperate and Tropical Seawater Systems at Monterey Bay Aquarium

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Abstract

The Monterey Bay Aquarium (MBA) features marine animals ranging from the tropics, subtropics, and temperate ocean zone including local species from Monterey Bay, Ca. Incoming seawater (~55° F) is warmed in secondary systems or locally in aquaria (up to 80° F) which can lead to seawater becoming supersaturated with atmospheric gases. This is a concern for aquatic organisms as bubbles can form within vascular system and tissue, often referred to as gas bubble disease (GBD). In this study we monitored total dissolved gas pressure (TDGP) using a saturometer (Pentair Lumi4 TGP Optical O2/Temp) in select exhibits. Solutions to mitigating gas supersaturation in existing life support at MBA are examined as well as best practices for performing TDGP measurements and processing the data.

Incoming seawater to the Aquarium first goes to the Kelp Forest Exhibit where monthly TDGP spot checks ranged from 102-105%. The Kelp Forest, in turn, supplies seawater to all other secondary systems and exhibits. Seawater is tempered and passes through de-aeration towers (DAT) prior to being distributed to the tropical exhibits. As such, tropical exhibit TDGPs were typically below 102%. However, subtropical exhibits do not have a main DAT downstream of the seawater supply line and TDGP measurements have been observed to fluctuate between 99 and 105% in monthly spot check measurements. Modifications to life support systems and methods for obtaining reliable TDGP measurements are discussed.

Gas super saturation of a Shark Aquarium without Air Exchange Tower

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Abstract

A newly renovated 2000 m^3 shark aquarium (SM), due to lack of space, has a fractionator and a 63 m^3 gas exchange tower. Immediately after sharks were introduced, dissolved oxygen [O_2] dropped to as low as $<$ 5 ppm. By using compressed air continuously, [O_2] was kept to $>$ 6 ppm. After one month, however, delta-P of total gas pressure (TGP) increased to 30 mmHg at 0.5m, as compared to 15 mmHg in a 5000 m^3 aquarium (T20) which has with sufficient gas exchange towers. We then measured [O_2], O_2%, TG % and delta-P at different depths in SM and compared with those in T20. We found delta-P and TG% in SM are much higher than in T20; however, [O_2] and O_2% are lower than in T20. The increased delta-P and TGP are likely caused by the accumulation of nitrogen gas due to insufficient gas exchanges in SM. To reduce nitrogen accumulation, aeration with compressed air was replaced with compressed O_2. After the replacement, the delta-P at 0.5m in SM decreased to 15mmHg on day 3rd; and within a month, other parameters at deeper depths reached the same level as in T20. In addition, due to insufficient gas exchange, [CO_2] is accumulated to 2ppm in the deep part of SM as compared to undetectable level in T20. High [CO_2] can decrease pH in aquarium. Laboratory experiments demonstrated that after stirring SM water for 6 minutes, pH of the SM water can increase to $>$ 8. Moreover, mortality of sharks decreased significantly: there were 13 mortalities during aeration with compressed air, and only 2 mortalities after replaced with concentrated oxygen up till now. In conclusion, for a healthy fish environment, the gas balance between air and water should be among one of the critical components required by any aquarium.

The Nightmare Before Christmas:
Losing Automation on a Holiday Weekend

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Abstract

The Downtown Aquarium is a 1.25 million gallon aquarium that houses close to 700 species and 10,000 animals. There are 10 large exhibit systems, three salt water recovery systems, fresh water and salt water supply systems managed by the life support staff. On December 22nd, 2016 between 10:00 and 11:00 pm the programming on one of three PLC cabinets was deleted, and the automation and controls were lost for 8 of 10 of the exhibit systems. Four aquarium team members manually balanced the affected exhibits throughout the night until enough staff arrived the following morning to try resetting the PLC cabinet, and an integrator could be contacted to help get the automation back online.

Supplemental Phosphorous and Organic Carbon Supplementation to Speed Nitrification

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Abstract

Chemical cycling of newly-constructed life support systems (LSS) through the use of ammonium salts or urea is standard practice in the aquarium industry. These artificial sources of nitrogen have long been used to facilitate growth of ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) in biofilters prior to the introduction of teleost fishes and other aquatic life, though the process has its limitations. All too often the cycling period essential for good water quality and animal health is cut short or otherwise constrained by the rigors of construction schedules, forcing aquarists and operators to expedite these microbiological processes as much as possible. Cycling of nitrite typically is typically more problematic than ammonia as NOB communities develop more slowly than AOB and must compete for space in biofilms. Though the cycling process promotes chemoautotrophic nitrification most species of NOB are facultative organoautotrophs, and as such can utilize organic compounds as the electron donor in nitrification. Supplementation of organic carbon (as sugar or ethanol) in addition to carbonates and bicarbonates has been found to enable NOB to more rapidly oxidize nitrite concentrations during cycling. Additionally, the supplementation of phosphorus (as phosphoric acid) has been used in aquaculture for years to similar effect to ameliorate “phosphate block” in cycling. The effect of each constituent on nitrification is quantified from small-scale trials, and the practical benefit observed from using both techniques in cycling of multiple mid-sized LSS is discussed. Options for sourcing a cost-effective, readily available substrate to provide both phosphorous and organic carbon are also presented.

A Diverse Microbial Consortium Drives Nitrogen Loss in Large-scale Aquarium Denitrification Sulfur Reactors

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Abstract
The removal of nitrate is critical for maintaining the health of animals in aquaria. For large systems such as the 6.3 million gallon *Ocean Voyager* exhibit of Georgia Aquarium, water changes are not a practical option for nitrate removal. Georgia Aquarium instead uses a sulfur oxidation-based denitrification system that exploits microbial metabolism to biologically convert nitrate to nitrogen gas. It remains unclear whether denitrification in this system, and others like it, is mediated by a dominant microorganism versus a consortium of potentially interacting species, and to what extent such a consortium may vary among systems. We characterized the bacterial communities in the *Ocean Voyager*'s denitrification system. This system (in its current form) has been in place since April 2015, and is comprised of two equipment pads each containing four denitrification towers. Although both pads remove nitrate, removal rates are highest in Pad 2. In both pads, a diverse assemblage of taxa potentially linked to sulfur oxidation and denitrification was detected in the tower water and attached to elemental sulfur pellets. These assemblages were dominated by the genera *Sulfurimonas* and *Thiobacillus,* which comprised an estimated 20-70% and 1-50% of microbial sequences. However, community composition differed notably between pads, with the relative abundance of *Thiobacillus* significantly higher in the more efficient Pad 2. Whereas the *Sulfurimonas* community was highly diverse and represented by over a hundred operational taxonomic units (OTUs), the *Thiobacillus* community was dominated by a single OTU. Metagenomic sequencing recovered genes for sulfur oxidation via three different pathways in three metagenome-assembled genomes (MAGs) belonging to the *Thiobacillus* and *Sedimenticola* genera. *Thiobacillus* MAGs also contained all genes for reduction of nitrate to dinitrogen gas, while *Sulfurimonas* and *Sedimenticola* MAGs lacked at least one gene to complete this pathway. Metatranscriptome sequencing revealed that *Thiobacillus* was most active on the sulfur pellets and *Sulfurimonas* was most active in the interstitial water, and that a diverse set of other taxa contributed to each step of sulfur oxidation-based denitrification. The results reveal a diverse consortium in the *Ocean Voyager* denitrification system, particularly within the *Sulfurimonas* genus. The composition of this consortium, and potential metabolic interactions among members, varies among pads and may underlie differences in nitrate removal rates.

Numbers, Spreadsheets and Graphs: 8 Tips to Effectively Record and Present the Things You Do Every Day

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Abstract

Information is critical to maintaining healthy aquatic environments, and most of the tasks that people in zoological roles perform can be tracked, analyzed, reported and stored. Effectively managing data streamlines workflow, reduces analysis time, reveals trends and optimizes processes. Clear presentation makes information easier to understand, and tailoring presentations to different audiences increases the information's persuasive ability. This presentation will cover 8 tips on working with and presenting data, with each step illustrated using an example data set from Georgia Aquarium. Topics covered will include properly setting up a spreadsheet for different applications, the practical use of basic statistics and programming, and advanced graphing techniques. Microsoft Excel will be used due to its universality, but the principals covered apply to any platform. No prior knowledge of statistics, programming or data management is required, however a basic understanding of Excel will be assumed.

Byproducts…we're all going to die!

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Abstract

The Oregon Zoo has a wide variety of aquatic exhibits including harbor seals, sea otters, penguins, and elephants all of which have some form of disinfection treatment. Introduction of a chlorine/acid system in conjunction with an ozone generator disinfecting the elephant exhibit brought concerns relating to byproduct formation potential and maximum contamination levels. Haloacetic acids and trihalomethanes were the main concern as exposure levels at or above the MCL could potentially increase the risk of certain cancers. In addition, long term exposure may cause negative effects on the liver, kidney, and reproductive system. Total trihalomethanes and haloacetic acids analysis were performed by TestAmerica. Results were compared to the EPA regulations for human drinking water levels. Tests were sent out during particular events: chlorine treated, ozone treated, chlorine/ozone treated, and post dump and fill. Results indicated that when calcium hypochlorite was used to maintain a concentration of 0.10-0.20 ppm free chlorine, total trihalomethanes were reported to be 0.0020 ppm. Total Haloacetic acids were found to be 0.0052 ppm. Results relating to the use of ozone as a main form of disinfectant reported total trihalomethanes at 0.0013 ppm and haloacetic acids were not detectable. Post dump and fill using city chlorinated water data showed that total trihalomethanes were 0.0013 ppm and total haloacetic acids at a concentration of 0.025 ppm. Data suggest that the use of chlorine as a main form of disinfection elevates total haloacetic acids and trihalomethanes levels compared to the use of strictly ozone disinfection, which displayed the lowest concentrations to date. In addition, strict protocol was incorporated into exhibit care as campus pools are dumped, deep cleaned, and filled on a specific schedule to reduce increasing concentrations of byproducts. Monthly byproduct testing on the elephant exhibit is also now part of the protocol.

Sand Filters and Beyond:
The Future of Life Support Design

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Abstract

Sand filters have been the "Go To" mechanical filtration method for aquatic animal life support system designs for the past 40 years. They are simple, cost effective and with the use of filter aids (including using ozone as a micro-flocculent) can produce excellent water clarity. However, with the increased desire to remove or reduce the use of oxidants in the system, a review of alternative treatment methods has been completed with the objective of optimizing the water quality and minimizing the space requirements, water consumption and capital and operational costs. By looking at existing facilities, installing a full-size pilot plants, and providing a mathematical model to extrapolate the data, an optimization of the full-scale systems was developed. This data will be presented.