Georgia Aquarium:

Handheld Meters Prove Invaluable For Measuring DO, pH Concentrations

By Joseph Lilli

Rugged, portable, easy-to-use instrumentation plays a vital role in providing accurate, repeatable measurements of DO, pH levels while transporting aquatic life long distances or monitoring aquarium water quality...as well as providing preprogrammed methods for multiple analysis and expanded data storage capabilities.

Visitors to the Georgia Aquarium in downtown Atlanta, the world's largest aquarium, describe it as *simply amazing*. And with good reason! It covers more than a million cubic feet (8.5 million gallons of fresh and marina water) and is home to more than 100,000 fish representing some 500 species from around the world. The largest tank, measuring 263 feet long x 126 feet wide x 33 feet deep at the maximum depth, holds 6.2 million gallons of water and houses two whale sharks along with some 10,000 animals. The second largest tank holds 800,000 gallons of water and is home to five beluga whales.

Equally amazing is the fact that the aquarium's 8.5 million gallons is ordinary tap water. Yet the world-class Veterinary Services Lab responsible for monitoring and maintaining water quality manages to keep the water clean and the animals healthy 365 days a year.

"The vast majority of water on the property is artificial seawater in a re-circulating setting," says Dr. Al Dove, manager of the aquarium's Diagnostic Laboratories. "To fill our tanks, we pipe in tap water, so we're not trucking it in

from the ocean. After treating it to remove chemicals and impurities, we turn this fresh water into salt water for marine habitats."

This procedure involves adding 750 2,000-pound sacks of Instant Ocean® sea salt, a total of 1.5 million pounds. Since the saltwater is made in-house, it comes with a substantial dollar value attached to it. Therefore, they take great pains to ensure they do not lose that water every time they backwash their filters or undergo other procedures. A comprehensive treatment and reclamation system cleans and recycles the water, losing only a little to evaporation and the protein skimmers that help remove debris.

Rigorous Water Quality Monitoring

Because the Georgia Aquarium is too far from the coast to access ocean water, the staff has to re-circulate its existing water. "That means we need very extensive monitoring programs to keep an eye on water quality at all stages," declares Dr. Dove, "because if something goes wrong in a re-circulating setting, you can contaminate or have problems with the whole system. We can't open up a gate and flush fresh seawater through the system like they can at many aquariums.

"Monterey Bay Aquarium, for example, is probably one of the best aquariums in the world. They are about as different from us as they can be and still be an aquarium because every night when everybody goes home, they throw open the valves and flush seawater right through their system. We don't have that luxury because we're 4 ½ hours from the coast," he adds.

With 75 exhibits, and some of them quite large, the water quality program at the Georgia Aquarium includes three types of filtration: mechanical filtration to remove fine particulates, fractionation to remove dissolved organic materials, and ozone, which plays the same role as chlorine in a swimming pool but is safer for fish. It takes 218 pumps moving 261,000 gallons of water per minute, 141 sand filters, and 70 protein skimmers to clean the whole aquarium. A computer handles nearly all of the decisions regarding clean and dirty water.

Even though the system is almost 100 percent self-sustaining, the Veterinary Services Water Quality Monitoring team conducts intensive water quality monitoring of every exhibit every day using portable handheld instruments and laboratory testing, while the Life Support Engineering Department conducts continuous in-line monitoring using a large computer system that also controls much of the life support equipment.

“We believe water quality plays a critical role in the health management of the animals,” Dr. Dove stresses. “For instance, if you look at fish disease in a broader sense, fish typically get sick because they are stressed – and usually because of poor water quality. If you can maintain good water quality, they won’t get sick in the first place. That’s the best preventive medicine there is.”

Accurate, Low Maintenance Handheld Meters

In its first tier water quality analysis, the Water Quality Monitoring team utilizes advanced automation technologies – specifically, the Hach DR5000 Spectrophotometer and the portable, handheld Hach HQ-series of water quality meters with patented Luminescent Dissolved Oxygen (LDO®) probes. The HQ-

series of meters and LDO probes have proven advantageous for measuring dissolved oxygen and pH levels when fish are being transported a great distance and in each of the exhibits.

In its second tier water quality analysis, the team uses Ion Chromatography, which measures, dilutes and analyzes samples, recording anything that is positively or negatively charged, and a high performance liquid chromatography system that measures antibiotic concentrations and anything abnormal that appears in the water.

“Hach, however, provides our workhorse chemistry, our workhorse equipment,” Dr. Dove says. “It provides the aquarium accurate, repeatable measurement, it’s portable, easy to use and calibrate, and is sufficiently durable to hold up in a seawater environment.”

When Dr. Dove began working at the Georgia Aquarium, the staff was using membrane-based technology. They discovered, however, that membrane-based meters were largely unreliable and very service intensive. “During my first six months here they all went in for service. I didn’t think that was good enough,” he says.

After switching to the LDO technology, they were pleased with the probe’s reliability, low maintenance, and the lack of a membrane to protect. And because the probe is self-contained, water doesn’t flow through the tip of the probe, making it more flexible in the harsh environment.

“We also liked its ruggedness. We had whale sharks lying on top of the probe in the shipping box, yet it suffered no damage. That probe is tough as nails,” Dr. Dove declares.

“I didn’t witness this myself,” he continues, “but I’ve heard the story about one of the sharks here actually biting into an LDO probe that was hanging in the exhibit. It looked a bit like a fishing lure on the end of a long string. The shark bit the probe and took it for a ride before letting it go, and it didn’t even have a scratch on it.”

The LDO probe is read by the Hach HQ40d Digital Multi-Parameter meter, providing immediate, simultaneous measurements of pH, conductivity and/or DO. The HQd-series of meters has an intuitive user interface with guided self-calibration, minimizing the chance for calibration errors. The last calibration as well as calibration history is stored in the plug-and-play probe, reducing the need to recalibrate when switching from one meter to another. The system provides reporting data, including time and date, sample ID, and user ID, so that users can store and monitor previous readings.

Depending on the particular application, the monitoring team uses either the Hach HQ30 or the HQ40d. “We particularly like the HQ40s,” Dr. Dove says, “because we can plug two probes into them at the same time and because they datalog. This allows us to collect information about the water quality parameters that we’re measuring and to download from the meter later on so we can analyze what happened.”

Maintaining DO, pH While Transporting

The HQ40d meter with LDO probe has proven especially valuable in the staff's management of long-haul transports and the changing of life support equipment. Dr. Dove says he and his chemist download data from the HQ. "I like to download data during long-haul transports and she likes to closely monitor water conditions when life support systems need to be shut down during equipment changes. Using this instrumentation helped us learn how to manage long-haul transports and how to manage systems when they are off-line.

"We usually have a limited time to transport the animals from a distant location to the aquarium. And, we don't have the ideal water treatment equipment when the animals are stuck in the belly of an airplane," adds Dr. Dove, "so we use the HQ meters a lot to help us manage the chemistry of the water on long-haul transports."

Recently, for instance, the aquarium had six whale sharks shipped 8,000 miles from Taiwan to the exhibit. The staff managed water quality during the entire transport using the HQ40d handheld meters with dissolved oxygen and pH probes attached to them.

They learned that if they managed pH levels early when transporting the whale sharks, they could save themselves a lot of trouble. Typically, throughout the duration of long-haul transports they were adding alkaline salts to offset the natural tendency of the pH to drop in the shipping container.

"By using the HQ meters, we discovered that if you concentrate those additions early in the flight and really stay on top of the pH, then it tends not to

drop so much in the first place," Dr. Dove says. "If you wait too long, you end up having to recover a lot of lost ground. That's information we wouldn't have had if the HQs hadn't been deployed."

When all transported fish finally arrive at the Georgia Aquarium, the staff again uses the handheld meters while helping the fish acclimate to their new surroundings. This process is especially critical because the water in the shipping container is markedly different from the water in the exhibit. The meters give the staff vital information pertaining to dissolved oxygen concentration (DO) and pH levels.

Dissolved oxygen maintenance is critical for supporting aquatic life, notes Dr. Dove, since fish absorb oxygen dissolved in the water directly through the blood vessels of the gills and skin. The water, therefore, needs to be at least 80 to 85 percent saturation because if the oxygen level in the water is too low, the fish will asphyxiate. While most of the exhibits in the Georgia Aquarium hover around 100 percent saturation, Dr. Dove says it's possible that some may be supersaturated with oxygen and have numbers exceeding 100 percent saturation. That's acceptable up to a point; otherwise, if there is too much oxygen in the water, it can result in gas bubble disease.

"The maintenance of pH also is extremely important," declares Dr. Dove, "because pH rules a wide range of physiological and biochemical processes. For instance, there are many enzymes that only work at certain pH ranges. If the pH deviates too much in either direction, you can really cause problems for animals. Thus, we regulate a steady internal pH. Most vertebrates are about 7.7, so if we

put a fish in water with a pH 4.5 and that fish is not adapted to living in 4.5 this sets up a substantial acid gradient from the outside to the inside. This wreaks havoc with the animal's ability to regulate its internal environment."

Portable metering probes at the Georgia Aquarium thus play a vital role in the monitoring and maintenance of water used in containers to transport fish and to sustain aquatic life in all aquarium exhibits. This instrumentation has proven it is highly durable, virtually maintenance free, and easy to use and calibrate – all while providing accurate, repeatable measurement. The LDO probe and HQ40d units have consistently demonstrated these capabilities day-in and day-out, thus ensuring the health and sustainability of more than 100,000 fish and animals.

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