NUTS & BOLTS

Monitor — or Else!

By Stephen K. Piggott

The risks associated with ignoring operating- and water quality parameters can ruin an aquaculture facility and bankrupt a business. A properly designed monitoring and alarm system will alert an operator before system conditions will no longer support life and identify the problem. It will also indicate when a piece of equipment is either over-performing or failing. An appropriate system of data management is important as well, as it will show whether conditions are changing over time, thus allowing the operator to anticipate future crises and take pre-emptive action before an emergency situation develops.

A Point Four PT4 system monitor at a recirculation facility in Chile.

The monitoring program for any facility is dependent on the system design and operational parameters. For example, the monitoring program for a high-density recirculation system, where a buildup of toxic metabolites can occur, can be very different from that required for a low-density, flow-through facility, where monitoring would focus on influent water flow and quality.

The essential information that should be monitored includes all aspects of water quality; however, operating conditions and parameters should also be included to allow evaluation of system performance. The following parameters (biased towards a recirculation facility) should be monitored:

Operational Parameters:

1. Total biomass (how do you know how much feed or oxygen, etc is required?)
2. Fish size (size and maturity impact feed conversion, sensitivity to water quality, etc)
3. System flow (how long does it take to exchange the water in a tank?)
4. Makeup water flow rate (how quickly are contaminants being flushed from the system?)
5. Tank rotating velocity (how fast are the fish being required to swim and therefore how much oxygen and food energy is required?)
6. Daily feed usage (how much oxygen is required and how much feces, ammonia and carbon dioxide is being generated?)
7. Feeding time of day (fish behavior and water quality change throughout the day primarily with respect to feeding time)
8. Oxygen usage (is it adequate for the fish in the system?)
9. Chemical addition (what else is going into the system to make it function properly)

Water Quality Measurements:

1. Temperature (are the fish being raised at their optimum temperature, what are the metabolic rates of the fish and bacteria within the system, and what are the saturation concentrations of the dissolved gasses?)
2. pH (helps define what percentage of the dissolved ammonia and carbon dioxide are toxic. It also affects the operation of the biofilter)
3. Alkalinity (is there sufficient buffering capacity to prevent extreme pH swings, and does the biofilter have enough raw material to function properly?)
4. Total suspended solids (and/or turbidity)

(this measure of solids-removal efficiency is an indicator of the biomass of bacteria that can live in the culture water consuming oxygen and discharging ammonia, carbon dioxide and other contaminants)

5. Salinity (salt is used to reduce disease and fungus outbreaks in fresh water systems; it also reduces the toxicity of nitrite and solubility of dissolved gases, but must be related to fish species and maturity. Critical for marine species!)
6. Dissolved oxygen (is the oxygen supplied going to the right place?)
7. Ammonia (is the biofilter working?)
8. Nitrite (a measure of biofilter operation, it also affects the chloride requirements in a freshwater system)
9. Nitrate (although only toxic at high concentrations, it is a good indicator of biofilter efficiency and of the system exchange rate)
10. Carbon dioxide concentration (carbon dioxide can interfere with the uptake of oxygen and shift the pH)
11. Total gas pressure (gas bubble disease can be caused by many things, including a pinhole in a pump intake or a disrupted oxygen hose on a venturi)
12. Hardness (calcium can be useful in reducing the impact of nitrite. Also, since the number of anions and cations are usually proportional, it offers a check on alkalinity measurements)
13. Trace elements or natural contaminants (like dissolved iron, manganese, sulfur dioxide, etc that are specific to a particular site or water source, and which could impair the health of the fish.

Some water quality parameters can be monitored continuously using sensors and probes that are mounted permanently within pipes, sumps and side boxes. These include flow rate, pH, dissolved oxygen (DO), electrical conductivity (EC - a measure of salinity), oxidation reduction potential (ORP - useful as an economical method to estimate dissolved ozone). Newer technologies include direct measurements of carbon dioxide and of ozone. The data are fed to electronic monitoring equipment that is designed to sound an alarm if the water quality degrades beyond preset limits. A valuable accessory to these systems is a data logger to record a continuous stream of data that can show changes over time. This is useful when determining diurnal variations within a system. Parameters such as DO, pH, EC and temperature can vary depending on the time of day or as a direct response to a feeding event, and can be plotted to allow a better understanding of the magnitude and duration of these changes. Hatchery management practices can then be adapted to minimize episodes of poor quality water, or reduce operating expense.

Another useful accessory is an auto-dialer, which can signal an operator by telephone after-hours, or who is outside the normal audible or visual signal range of a local alarm system.

Other water quality parameters require sampling by operators. Water quality parameters such as ammonia, nitrite, nitrate, alkalinity, hardness, TSS, TGP, turbidity, salinity and carbon dioxide are usually obtained by sampling an aliquot of culture water from a specific location within a culture system at a specific time of day. The water is then tested using reagents and a colorimeter, a hand probe or similar type of testing equipment. Many operators are tempted to minimize these much more labour-intensive types of sample gathering. However, this information can be vitally important when diagnosing a problem or optimizing system performance. Logging of the data into a computer system for analysis of changes over time, or in relation to other parameters, is a necessary step that is frequently ignored by system operators, who are then surprised by a fish kill or when operating costs begin to skyrocket. The sampling interval must be based on the sensitivity of the facility to change — the speed with which the system would crash if parameter went beyond the safe operating range. In high-density, low exchange rate systems, some water quality parameters can degrade much faster than in less intense facilities. The sampling interval should be adjusted accordingly. For these types of measurements, sampling intervals (after diurnal variations have been examined and understood) are typically once or twice per day, but should be adjusted to suit the facility.

The YSI 5200 Recirculating System Monitor installed in 2004 at a horseshoe crab farm in Taiwan.

Other parameters such as fish size and stocking density are normally measured by capturing a representative sample of the fish, or measuring a few during fish handling events like vaccinations or transfer between

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tanks. As most fish species find handling extremely stressful, these sampling events are normally minimized. Estimates by experienced operators, based on changes since the last direct sampling, can normally be substituted for direct measurements. However, it is still important to record the values, as predictions on feed usage and metabolite generation are directly related to biomass, and to monitor water quality parameters as a function of fish size or biomass.

A wide range of monitoring and testing equipment exists, and nothing prevents a small outfit from substituting a labour intensive hand-sampling program for more expensive electronic monitoring equipment. However, very few aquaculture facilities can afford the risks and costs associated with ignoring water quality parameters entirely.

Stephen K. Piggott, M.Eng., P.Eng., is a professional engineer with PRAqua of Nanaimo, BC. With 16 years' engineering experience, Stephen has been integral in the design of several aquaculture research facilities including design of seawater supply and bio-secure effluent systems, and used non-conventional equipment to meet water quality targets. For more information contact Stephen at: +1 250 714 0141, or by .mail at: info@praqua.com