

NUTS & BOLTS

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Monitoring for Success

A properly designed monitoring and alarm system detects when water quality and system operating parameters fall outside set values, giving operators time to take corrective action.

Knowing what to measure, and how to measure it, is central to effective facility management, and critical to successfully meeting health and growth objectives. Monitoring, alarm and control systems constitute the nerve centres of well designed intensive aquaculture facilities.

A facility's monitoring program is a function of the culture system design and operating parameters. For example, the monitoring requirements for a high density recirculation system, where concentrations of toxic metabolites can build up quickly, will be very different from those required for a low-density, flow-through facility, where monitoring would normally measure only influent water flow and quality.

A properly designed monitoring and alarm system detects when water quality and system operating parameters fall outside set values, giving operators time to take corrective action. Such monitoring systems can also detect when a piece of equipment is malfunctioning. An effective 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.

SCADA (Supervisory Control and Data Acquisition) systems are sophisticated closed-loop control systems, which monitor and log entire aquaculture operations in real time, and are programmed to take corrective action on their own. SCADA represents the current 'pinnacle' of remote monitoring and process control.

The essential information that should be gathered by the monitoring system includes several expressions of water quality and operating conditions that permit full and timely evaluation of the aquaculture system's performance.

Operating Parameters:

- ❖ Total biomass: Essential for determining feed and oxygen requirements
- ❖ Fish size: size and state of maturity affect feed conversion and sensitivity to water quality, etc.
- ❖ System flow: How long does it take to exchange the water in a tank?
- ❖ Makeup water flow rate: How quickly are contaminants flushed from the system?
- ❖ Water rotational velocity: How fast are the fish required to swim, and therefore how much oxygen and food energy are required?
- ❖ Daily feed usage: How much oxygen is required and how much feces, ammonia and carbon dioxide is generated?
- ❖ Feeding time of day: Fish behavior and water quality change throughout the day primarily with respect to feeding time.
- ❖ Oxygen usage: is it enough to support the fish in the system?
- ❖ Chemical addition: What else is going into the system to make it function properly?



PT4 monitor showing read outs for oxygen concentration, pH and temperature.



Above: YSI 5200 unit mounted on an outdoor tank.

Water Quality Factors:

- ❖ 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 gases?
- ❖ pH: defines the concentrations at which dissolved ammonia and carbon dioxide become toxic. It also affects the operation of the bio-filter.
- ❖ Alkalinity: Is there sufficient buffering capacity to prevent extreme changes of pH, and does the bio-filter have enough raw material to function properly?
- ❖ Total suspended solids (and turbidity): this provides a measure of solids-removal efficiency, and is also an indicator of the bacterial biomass in the culture water that is consuming oxygen, and discharging ammonia, carbon dioxide and other contaminants).
- ❖ Salinity: Common salt is used to reduce disease- and fungal outbreaks in fresh water systems. It also reduces the toxicity of nitrite and the solubility of dissolved gases, but must be related to fish species and maturity. Critical for marine species!
- ❖ Dissolved oxygen: Is the oxygen supplied going to the right place?
- ❖ Ammonia: Is the bio-filter working?
- ❖ Nitrite: A measure of bio-filter operation. It also affects the chloride requirements in a freshwater system.
- ❖ Nitrate: Although only toxic at high concentrations, it is a good indicator of bio-filter efficiency and of the system exchange rate.
- ❖ Carbon dioxide: High concentrations of CO₂ can interfere with the uptake of oxygen and lower the pH.
- ❖ 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.
- ❖ 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).
- ❖ Trace elements or natural contaminants: Dissolved iron, manganese, sulfur dioxide, etc, that are specific to a particular site or water source, could impair the health of the fish.

Newer technologies

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), and 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 is a data logger that records continuous streams of data and can show changes over time. This is useful when determining diurnal variations within a system.



A central control panel. The four YSI 5200 units are monitoring different sub systems of the facility.

Parameters such as DO, pH, EC and temperature can vary depending on the time of day or as a direct response to a feeding (or other) 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 to telephone an operator after-hours, or alert someone outside the normal audible or visual signal range.

Other parameters

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 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, that is, the speed with which the system would crash if any parameter went beyond the safe operating range. In high-density, low exchange systems, some water quality parameters can degrade much faster than in less intense facilities, and 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 local conditions.

Fish sampling

Other parameters such as fish size and stocking density, are normally measured by capturing a representative sample, or measuring a few during events like vaccinations or transfer between tanks. As most fish species find handling extremely stressful, such sampling events are normally minimized. Estimates by experienced operators, based on changes since the last sampling, can normally be substituted for direct measurements. However, it is still important to record the values (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, few (if any) aquaculture facilities can afford the risks and costs associated with ignoring water quality parameters entirely.

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