Aquacultural Engineering Society News

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Letter From Your President

Dear Members,

The Aquacultural Engineering Society was born of a desire by a group of engineers to build a home for engineering professionals in the world of aquaculture. Founded in 1993, the society today is having an impact and making a difference in the international world of aquaculture. In 1998, the AES sponsored the engineering sessions at *World Aquaculture 98'* in Las Vegas and at *Aquaculture Europe* in Bordeaux, France. In 1999 the AES sponsored the engineering sessions at *Aquaculture America* in Tampa, Florida and is set to host two days of engineering sessions at *World Aquaculture 99'* in Sydney, Australia. Additionally, we will be holding a special members only "*AES Issues Forum*" in North Carolina in November (For more information see the announcement in this newsletter.).

At the same time, we are working with Elsevier Scientific Publishers to continue the excellence of our Journal, *Aquacultural Engineering* and to explore ways to bring books and conference proceedings to the public at reasonable costs. This outstanding publication has increased to 8 issues per year in 1998 to provide an expanded venue for authors. Additionally, this past year, under the guidance of our publications committee chair Dr. Jaw-Kai Wang, the AES launched a very well received "Aquacultural Engineering" Column in the US based trade magazine "*Aquaculture*."

However, all of these things do not just happen. They have taken much time and effort from a group of dedicated AES members. To keep up the momentum, the involvement of the greater membership is necessary. Our program committees for the *Aqua 2000*, a joint meeting of the WAS and EAS in Nice, France and *Aquaculture America 2000* in New Orleans can use your input (see the UPCOMING MEETINGS section inside). If you have engineering articles appropriate for a trade magazine, please contact Dr. Wang for consideration of publishing your article in our engineering column in *Aquaculture Magazine*. With 220 members worldwide, the AES needs your help to grow and maintain excellence in it's programing.

If you would like to be more involved in the society or have any questions or suggestions, please contact me by mail at NC State University, Campus Box 7646, Raleigh, NC 27606 USA, by phone at (919) 515–7587, by Fax at (919) 515-5110 or by email at Tlosordo@unity.ncsu.edu .

I look forward to hearing from you or seeing you in Sydney or Raleigh during the coming year!

With Best Regards,

Tom Losordo

Thomas M. Losordo, President
Aquacultural Engineering Society

Inside:

Membership Dues

The AES is collecting 1999 membership dues. If you have not already joined the AES for 1999, you can still join and receive eight issues (two 1999 volumes) of the journal *Aquacultural Engineering, the AES News,* and the AES Member Directory.

Aquacultural Engineering Journal Subscriptions

The last *Aquacultural Engineering* journal issue (Vol. 19, No. 4) was sent to all 1998 AES journal-receiving members with this newsletter. We will begin shipping the next issue of the *Aquacultural Engineering* journal to 1999 AES journal-receiving members this spring. Be sure that you have renewed your AES Membership for 1999 in order to receive *Aquacultural Engineering* volumes 20 and 21.

Computer Monitoring & Control Technology, Part I: What, Where and How.

By James M. Ebeling, consulting research engineer for the Conservation Fund's Freshwater Institute, jebeling@wam.umd.edu.
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INTRODUCTION

The idea that "aquaculture is agriculture" has almost been universally accepted and like today's livestock production, aquaculture is rapidly moving toward intensive, controlled environments in the form of intensive recirculation systems. With this new technology comes a significant increase in production, but at the cost of increased risk of catastrophic loss due to equipment or management failures. In addition, managers of these intensive production facilities need accurate, real-time information on systems status and performance in order to maximize their production potential. Current technologies are allowing fish stocking densities of over one pound per gallon of water. At these densities, failure of a circulation pump or aeration system can result in severe stress to the fish or even significant losses within minutes. Expensive and sophisticated systems and components from other industries, such as the wastewater and petroleum industries, have been successfully modified for use in aquaculture. Though only a small fraction of their potential power is usually employed, due to aquaculture's relatively simple monitoring and control demands (i.e. digital inputs/outputs). Today with the rapid decrease in costs for computers, software, and off-the-shelf monitoring hardware, monitoring and control systems are within the reach of even small producers and mandatory for large scale production facilities.

Before going any further though, it should be emphasized that the most sophisticated (and normally under appreciated and paid) monitoring and alarm system is an attentive human operator. Experienced staff can detect the moment he or she steps into a facility whether something is amiss, often just from the change in background noise. In the real world though, most facilities are not staffed 24 hours a day. Moreover, the watery environment of aquaculture is totally different from what most "air-breathing" operators are accustomed too, requiring the need for monitoring of critical water quality parameters and system components.

What follows are answers to some of the basic questions about monitoring and control systems in aquaculture: *who, what, where, how and why*? The answer to the first question is obvious, anyone who hopes to be successful in aquaculture. To this end, several types and levels of monitoring and control systems will be described that should be affordable and appropriate for the simplest single tank system to the sophisticated commercial producer.

Questions to be asked in determining how sophisticated the monitoring/control system should be, include:

- *type and size of the facility*: is it a hatchery, fingerling production or growout system, broodstock maintenance, high school project, cold water or warm water facility, located in a single building or multiple buildings.
- *type and number of tanks/systems*: tanks, raceways, aquariums, numerous small rearing tanks or large production tanks, aeration with air or oxygen injection, degree of recirculation.
- *stocking density and value of fish*: semi-intensive, intensive or super "just keep them wet" intensive systems, broodstock, quick turn around fingerling production, grow-out, trout, tilapia or expensive show Koi.
- *location and management style*: remote location or on-site staff 24 hours per day, full or part-time operators.
- *budget*: just an audible alarm in the office, or a microcomputer controlled system with automatic back-up response, telephone dialer, with remote access and control through the Internet via a Web Page.

The answer to "*why*" is also obvious when working with any live animal, be it a simple algae to an endangered sturgeon. What, where, and how to monitor make up the majority of Part I of this article, with hopefully enough detail so that decisions can be easily made and systems designed to meet individual needs. In Part II, techniques for bring all the alarms together

Table 1. A short list of potential "emergencies" in Aquaculture

Type/System	Causes
"beyond your control"	flood, tornadoes, wind, snow, ice, storms electrical outages, vandalism/theft.
staff errors	operator "errors", maintenance overlooked causing failure of back-up systems or systems components, alarms deactivated.
tank water level	drain valve opened, standpipe fallen or removed, leak in system, overflowing tank.
water flow	valve shut or opened too far, pump failure, loss of suction head, intake screen plugged, pipe plugged.
water quality	low dissolved oxygen, high CO_2, supersaturated water supply, high or low temperature, high ammonia, nitrite, or nitrate, low alkalinity.
filters	channeling/plugged filters, excessive head loss.
aeration system	blower motor overheating because of excessive back-pressure, drive belt loose or broken, diffusers plugged or disconnected, leaks in supply lines.

will be reviewed, ranging from simple telephone dialers to sophisticated computer based systems.

WHAT CAN GO WRONG?

Murphy's Law states simply: if anything can go wrong, it will (author note: "and usually at 4:00 am on a Sunday morning"). Determining what can go wrong and making a list of worst case scenarios is a never-ending quest. From personnel experience, no matter how hard you try or how long your list is, there will always be a surprise waiting around the next corner and usually at the worst possible moment. A short list of some potential "emergencies" is presented in Table 1. It makes a good place to start, after that let your imagination go wild, anything is possible! Remember though, that it is also important during this initial design process not to go overboard in terms of technological complexity or in the sheer number of monitoring points and alarms. Sophisticated alarm systems are of little use, if the part-time help disarms them due to their unreliability and frequent false alarms.

While compiling this list, keep in mind the relative importance and the required response time for each of the water quality parameters or monitored components (Table 2). Life support priorities in aquaculture start with water, followed immediately by adequate levels of dissolved oxygen. Then come the other water quality parameters, correct temperature, pH, and alkalinity, and finally low concentrations of ammonia-nitrogen, nitrite, nitrate, and carbon dioxide. At high stocking densities (greater than 1/3 lb/gal), dissolved oxygen requires the most rapid response time. If the water flow or aeration is cut for any number of reasons, low oxygen and the resulting stress can lead to disease problems and/or mortality within minutes. Thus in the design of intensive systems, a simple audible alarm in the office may not be adequate, or even a pager if the manager lives 20 minutes away. Thus in addition to the monitoring, some form of backup aeration must be provided for and automatically engaged to insure survival of the fish. The other water quality parameters listed above change more slowly than dissolved oxygen and can take hours or days to reach levels of concern. Thus allowing more time to analyze the problem and take the necessary steps to correct them.

Table 2. Life Support Priorities in Aquaculture

<u>High</u>
(fast response time – minutes)

electrical power
water level in tank
dissolved oxygen –aeration system/ oxygen system

<u>Medium</u>
(moderate response time – hours)

temperature
carbon dioxide

<u>Low</u>
(normally slowly changing – days)

pH
alkalinity
ammonia-nitrogen
nitrite-nitrogen
nitrate-nitrogen

WHERE TO MONITOR?

At low stocking densities (less than 1/3 lb/gal), basic parameters to be monitored include system electrical power, tank water level (high and low), aeration system pressure, and water flow through the filters and tank. All of these parameters can be monitored as simple digital sensors, i.e. either on or off. Analog sensors, such as dissolved oxygen levels, are more expensive to utilize and are more important at high stocking densities or where pure oxygen aeration is used. For all these parameters, it is as important where you monitor critical parameters, as what you monitor. For example, it helps little to monitor flow from a pump into a tank, if the drain line is left open, and all the water is flowing out as fast as it is flowing in. What is important from the viewpoint of the fish is the tank water level. Similarly, there is no advantage in monitoring the power to a pump, if the discharge valve is shut or the motor thermal-overload switch has turned the pump off. The critical parameter to monitor is whether there is flow from the pump. Finally measuring air pressure next to the aerator is of little help, if there is a major leak at the far end of the distribution system, resulting in low air pressure for the last tanks on the line. The aeration pressure need to be monitored at the farthest point in the system from the air blower. Table 3 lists some of the important systems and parameters that need to be monitored in intensive recirculation systems.

WHAT TO MONITOR?

Sensors in aquaculture can be roughly divided into two major types: digital (on/off signals) such as water level, aeration pressure and water flow switches and analog (continuous output) such as dissolved oxygen, temperature, pH, conductivity and ammonia-nitrogen probes. In addition, most analog probes require

Table 3. Important Systems or Parameters to Monitor

electrical power	single and three phase supply individual systems on GFIC's
water level	culture tank (high/low) supply sumps to pumps (high/low) head tanks/ reservoirs (high/low) chemical storage tanks filters (high/low)
aeration system	air/oxygen pressure
water flow	pumps culture tanks submerged filters in-line heaters
temperature	culture tanks (high/low) heating/cooling systems (high/low)
security	high temperature/smoke sensors intruder alarm

some additional hardware or controllers to convert the probe output to a usable signal, provide a digital display and allow for calibration and zeroing. Thus the higher cost for these types of measurements, compared to simple switch closures. Below is a short list of important monitoring parameters:

ELECTRIC POWER

Power failure is probably the most common emergency situation and the one most easily monitored. This is especially important when systems such as filters or supply pumps are located some distance from the main building. Three-phase power can be especially confusing, because if only one phase is down, it is possible to lose power to some systems, but not all. Murphy's Law assures that the monitoring system will not be on the one phase that goes down. In addition, when this happens, severe damage can occur to three-phase motors and pumps, if not properly protected. One often overlooked result of power outage is the loss of lights, which means that either numerous flashlights need to be maintained in good working order or back-up emergency lighting provided. When the power goes out, back-up generators suddenly become worth their weight in gold, as long as they are properly maintained and regularly tested.

WATER LEVEL

Probably the easiest and most inexpensive parameter to measure, water level should be monitored for both high and low levels at the minimum in each production tank. High/low water level sensors will detect plugged drain lines, fallen standpipes or drain lines accidentally left open. Level sensors should be protected, so that active fish do not accidentally trigger them. Other locations to monitor include the intake side of pumps in wells or sumps. These should provide for automatic shutdown of the pumps to prevent their damage in the case of low water levels. Supply reservoirs or head tanks need to be monitored for both high and low levels. High levels can indicate unusual change in normal water demands, due to clogged pipes or valves accidentally turned off. Low levels can be caused by pump or water supply failure. If immersion heaters are used, low level monitoring should be designed to turn them off, to prevent overheating and burning out of the heaters and melting pipes. Alarm levels should be set so that normal operating transient do not activate an alarm. This can be accomplished either by setting the levels optimistically or by allowing some time delay before an alarm is activated after a sensor is triggered.

AERATION SYSTEM PRESSURE

The aeration system is one of the most critical systems in any intensive recirculating aquaculture system. Response time to failure is very short, and both monitoring and backup systems are important. Low pressure in the system may mean a ruptured airline, open or jammed pressure relief valve, disconnected diffusers or blower failure. Although not as often monitored, excessive high pressure could indicate blocked supply lines, valves turned off or clogged diffusers.

WATER FLOW

In some cases, the actual measurement of flow rate is important, such as chemical injection systems for dechlorination or for monitoring system performance. Normally, monitoring whether water is actually flowing (flow/no-flow) with a digital sensor is adequate. One example is in-line heaters that require continuous water flow to prevent overheating and meltdown. Another example is submerged biological filters, where anaerobic condition due to pump failure can be damaging to the nitrifying bacteria.

DISSOLVED OXYGEN

Dissolved oxygen is one of the most expensive and difficult to monitor continuously. Thus deciding whether to continuously monitor it is dependent on the overall economics of the system, stocking density and degree of risk a manager is willing to accept. Normally the actual value of dissolved oxygen is not need, just whether it is above or below a given set point. Thus what should be a simple digital signal, ends-up requiring both an expensive probe and a sophisticated hardware interface. The availability and costs of both oxygen probes and hardware has dramatically improved in the last few years, but still remains too high.

TEMPERATURE

The continuous and precise monitoring of temperature in production tanks is important to optimize production, reduce stress and minimize risk of disease. Systems should be monitored for both excessive high and low temperatures, keeping in mind the two extremes are not equal. While low temperatures may reduce growth, excessive high temperatures may yield a new career path. Since most temperature controllers are cyclic in nature (either on or off), temperature alarm limits should not be set too close together, to prevent unnecessary alarms due to short term transients.

OTHER WATER QUALITY PARAMERS

Other water quality parameters, pH, ammonia-nitrogen, nitrite, nitrate, alkalinity, and carbon dioxide vary relatively slowly in comparison to dissolved oxygen. Although probes and systems are available at a high cost to monitor these parameters, the most cost-effective method is daily or weekly monitoring with inexpensive off-the-shelf test kits.

PHYSICAL PLANT SECURITY

Readily available, intrusion alarms, smoke and high temperature sensors (fire) are commonly used to protect against fire, theft and vandalism. Often existing systems can be connected to the proposed monitoring system.

HOW TO MONITOR?

Over the past few years, the cost of computer hardware and software has dramatically decreased, while the processing power and computer programming sophistication has greatly increased. Sensor technology has become more reliable and sophisticated with such innovations as embedded microchips in the sensors for signal processing and linearization. A large number of sensors and monitoring systems components have been borrowed from the wastewater treatment and chemical and petroleum industry. In many cases, the sophistication and corresponding expense of these types of monitoring and control equipment are not necessarily required in aquaculture facilities. Nevertheless, until specific equipment becomes available for aquaculture and for high valued products, the added costs of this equipment may be justified. Keep in mind, that for any monitoring system, its overall reliability is determined by the most unreliable part (i.e. weakest link).

The following description of sensors represents the simplest and most cost-effective solutions to monitoring each individual parameter. For each of these thought, there exists a multitude of solutions, some more expensive, more accurate, more reliable, more precise, with better interface capabilities, or simply available. There is no simple right or wrong solution, and this is where the engineering and design comes to play.

WATER LEVEL – Float Switches

Water level is probably the easiest and most inexpensive parameter to measure. The basic float switch is designed to monitor a single, discrete, preset liquid level. Simple float switches are constructed with a float containing a small magnet, which moves with the water level and actuates a hermetically sealed reed switch within the stem or body of the float switch. The rugged construction of this design provides for long and trouble free service with minimum maintenance requirements. Several different designs are available for mounting either vertically or horizontally in the tank or sump. Two float switches can be wired in series to monitor both high and low levels in a tank. Although most float switches are designed to handle 110 VAC at small currents, they should be powered by low voltages (i.e. 24 VAC or DC) to minimize danger to personnel and fish. Float switches are simple, foolproof, and relatively inexpensive. Examples of two float switches that are commonly used are Aquatic Eco-Systems Liquid Level Switch ST-3M and Grainger Liquid Level Switch 2A554.

Other options for monitoring water level include optical liquid-sensing sensors that use an internal infrared circuit and the light refracting properties of water. Non-contacting ultrasonic level sensors measure the time required for the ultrasonic pulse to travel to the water surface and return. Conductivity level switches operate by detecting a small electric current between a single electrode probe and a grounded metal tank or between two electrodes. Finally, pressure sensing systems use a pressure transducer to measure the pressure required to bubble air through an immersed pipe in the water column.

AERATION SYSTEM PRESSURE

Pressure is defined as a "force per unit area", which is to be used to produce a deflection, distortion or some other physical change in a sensor. A pressure control switch uses this deflection to trip an electrical switch at a preset pressure setting. Low and high pressure switches are available in a wide variety of configurations and price scales, from numerous manufacturers. One examples of a pressure switch that have been commonly used is Aquatic Eco-Systems Pressure Switch.

WATER FLOW - Drag discs, paddle and vane flow switches

Drag discs, paddle and vane flow switches are all designed to monitor flow/no-flow or low flow conditions. Each operates on the drag force of the moving water against a small disk, paddle or vane in its path, which controls a small micro-switch. They are available in a wide range of flow rates and pipe sizes. Normally drag discs and paddles are installed using a "Tee" fitting and vane types are installed in-line. An example of a flow switch that has been commonly used is Aquatic Eco-Systems Flow Switch, ST-9.

Other options for monitoring flow are rotameters. As the water flows through the rotameter, it raises a float in a tapered tube, increasing the area for passage of the fluid. The greater the flow, the higher the float raises in the tube, which is directly proportional to the flow rate. The float reaches a stable position, when the upward force exerted by the flowing water is equal to the downward force exerted by the weight of the float. These flow meters can be used to monitor flow by mounting a proximity switch externally, which is switched at a predetermined flow rate by a small magnet in the float. A second more expensive option is to use a turbine or paddlewheel flow meter. The flowing water turns a small turbine blade or paddlewheel and an electrical pulse is generated. This is sent to the appropriate hardware, where the flow rate or the total flow can be displayed and alarm conditions set and low/high flow alarm relays activated.

DISSOLVED OXYGEN

Over the past few years, there have been introduced a number of dissolved oxygen probes and analyzers designed specifically for the aquaculture industry. Most of these are microprocessor-based instruments capable of measuring levels of dissolved oxygen up to 100 PPM, important for monitoring oxygen injection systems. Standard recorder outputs (0 – 5 VDC) are built-in and many include 4-20 mA current loop outputs. Several models also provide serial outputs (RS-232, or RS-485) for direct interfacing with microcomputers and local area networks (LAN's). These also include high/low set point control relays for controlling external devices such as aerators, pumps, valves or other alarm monitoring equipment. Although the initial investment in this equipment can be high, it must be weighed against the potential loss and poor growth due to low dissolved oxygen levels. Dissolved oxygen meters designed specifically for aquaculture are available from Point Four Systems, Inc., YSI, Inc. and Royce Instrument Corp.

OTHER WATER QULAITY PARAMETERS

pH, temperature and other water quality parameters usually have a relatively long response time when compared to dissolved oxygen or the effects of pump or aeration failures. Thus these and other slowly changing parameters are probably best measured as part of a regular water quality monitoring program using bench-top laboratory equipment. Although equipment exists for continuous monitoring of pH and temperature for example, except for research purposes, it is not normally required in production aquaculture. On-line ammonia monitoring is feasible, but very expensive and difficult in practice.

Now that we have the answers to what, where, and how to monitor critical parameters, the question becomes how to integrate them into a control/monitoring system. In Part II of this series, techniques for bring all the alarms together will be reviewed, ranging from simple telephone dialers to sophisticated computer based systems.

Trade names are used for clarity only and do not imply endorsement of products by the Aquacultural Engineering Society, nor is criticism implied of other manufacturers of similar products, which are not included.

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Computer Monitoring & Control Technology, Part II: Putting the System Together

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INTRODUCTION

Commercial aquaculture today is rapidly moving towards intensive recirculation systems. The ability to optimize water quality and temperature, year round, in these systems allows for the continuous production of a premium market, high value fresh fish. In these systems, the key to optimizing production is the maintenance of good water quality (dissolved oxygen and ammonia levels) and optimal temperatures for maximum growth and survival. With this new technology comes a significant increase in production capability, but at the cost of increased risk of catastrophic loss due to equipment or management failures. At high production densities, failure of a circulation pump or aeration system can result in severe stress to the fish or even significant losses within minutes. To overcome this problem, some form of continuous monitoring/control system and reliable backups are mandatory. Today with the rapid decrease in costs for computers, software and off-the-shelf monitoring hardware, monitoring and control systems are within the reach of even small producers and mandatory for large-scale production facilities. Benefits of monitoring and control systems in aquaculture include increased process efficiencies, reduced energy and water requirements, reduced labor costs, improved accounting and management and reduced stress and disease potential (Lee, 1998).

As mentioned in Part I, it should again be emphasized that the most sophisticated (and normally under appreciated and paid) monitoring and alarm system is an attentive human operator. Experienced staff can detect the moment he or she steps into a facility whether something is amiss, often just from the change in background noise. In the real world though, most facilities are not staffed 24 hours a day. Moreover, the watery environment of aquaculture is totally different from what most "air-breathing" operators are accustomed too, requiring the need for continuous monitoring of critical water quality parameters and system components.

In Part I, the answers and solutions were presented to some of the basic questions about monitoring and control systems in aquaculture: who, what, where, how and why? In part II, several types and levels of monitoring and control systems will be described that should be affordable and appropriate for the simplest single tank system to the most sophisticated commercial producer.

AUTOMATIC PHONE DIALERS

The final step in the development of the monitoring/control systems is to bring each of the potentially catastrophic alarms described in Part I to the attention of the manager and staff, especially when they are home sleeping. A very inexpensive, simple and versatile monitoring system can be constructed around readily available automatic telephone dialers/alarm systems. These units are readily available for a wide range of inputs, sophistication, and costs. One such unit, the Sensaphone (Phonetics, Inc., Aston, PA) has been used in numerous research and production facilities with excellent results. The Sensaphone unit automatically monitors the following conditions:

- AC electric power – power failure.
- four digital alert inputs or 3 digital and 1 temperature.
- temperature – reports actual temperature and checks for high or low limits.
- high sound level – fire/smoke alarm, intruder alarms, unauthorized parties.
- battery status – condition of its battery back-up.

All monitoring is continuous and when an alarm condition occurs, the unit announces the alarm status locally for 30 seconds. If no response is received, it then sequentially dials up to four user-programmed telephone numbers (including pagers) with an alarm message. It will state in English the existing problem, disconnect and wait for an acknowledging telephone call or coded response. It will continue dialing-out, up to sixteen attempts, until its message is properly acknowledged. In addition, it is also possible to call in and listen to a status report on the monitored conditions and hear the background sounds through a built in microphone. For most small systems, this would provide the necessary digital inputs for monitoring tank water level (high/low), aeration systems pressure, water flow, and sump water level or if desired, system water temperature.

THE BASIC SYSTEM

The basic monitoring system was designed for low-density (less than 1/3 lb./gal) recirculating systems, with aeration only and moderate feed rates, such as broodstock holding tanks, isolation/quarantine tanks or educational systems. Basic system parameters (level, pressure, flow) are monitored by digital sensors, i.e. either on or off. Analog sensors, such as temperature and dissolved oxygen levels, are more difficult and expensive to utilize and are important only at much higher stocking densities or where pure oxygen aeration is required. Basic parameters to be monitored at this production level include electricity, tank water level (high and low), aeration system, and water flow. The actual number of subsystems monitored, depends on the specifics of the system design and the operating conditions. In most cases, only a few monitoring points should be necessary. Parameters monitored and sensors used include:

- system electrical power: monitored directly using the Sensaphone or indirectly due to loss of other subsystems (pump flow, aeration, etc).
- tank water level (high/low): Aquatic Eco-Systems, Liquid Level Switch ST-3M - , or Grainger Liquid Level Switch 2A554.
- aeration system pressure: www. aquatic-eco.com" Aquatic Eco-Systems, Pressure Switch B601.
- flow-sensing switch: Aquatic Eco-Systems, Flow Switch ST-9.
- telephone dialer: Aquatic Eco-Systems. SensaphoneTelephone Alarm System.

Each of the sensors is wired directly into a Sensaphone input, with the two float switches wired in series to monitor both high and low water level. The fourth input on the Sensaphone could be used to monitor either temperature of the water or an additional alarm. With this system design, a single tank or perhaps several could easily be monitored for the basic system parameters: water level, flow, aeration and electricity.

INTERMEDIATE SYSTEM

The next stage up from the basic monitoring package is to literally add 'bells and whistles' to the system. One of the primary disadvantages of the above system is that it works fine for a single tank, but is difficult to expand to multiple tank systems. It is also difficult to disable a single alarm input during routine cleaning operations, such as the tank low-level alarm. To overcome these limitations and to add visual indicators that system alarms are active, several modifications and additions were added over the years to this basic design. The first was a 24 VAC DPDT (Double Pole, Double Throw) relay, that is always energized when the sensor is in its normal state, i.e. non-alarm condition. The primary advantage of this design is that failure of the sensor or a break in the wire connections causes an alarm condition to occur. In addition, the sensor is energized at a low voltage (24 VAC or DC), thus minimizing risk to operator and, more importantly, the fish. Adding an LED (Light Emitting Diode) allows the operator quickly to visually determine the status of the alarms. The additional relay contacts can also be used to provide several additional outputs, such as audible alarms and switch closures for the telephone dialer. In addition, a SPST (Single Pole, Single Throw) switch can added to the alarm output, allowing it to be turned off during routine maintenance or when the production system is down. This can also be wired to an alarm status green LED, which when turned off, indicates the alarms deactivation. Thus, an operator can tell at a quick glance the system monitoring status and alarm status. More details and wiring diagrams for this and several other systems can be found in the references Ebeling, 1995, and 1997.

COMPUTER BASED SYSTEMS

Once it becomes necessary to monitor analog inputs, such as dissolved oxygen, pH, temperature or output analog signals for control purposes, some form of computer based system must be employed. With this added capability though, comes the cost of additional requirements for calibration of the probes and sensors and maintenance of the overall system. The utilization of computer control and monitoring systems in aquaculture has until recently been limited, with only a few systems custom-designed for research or large commercial operations (Lee, 1995). The vast majority of small producers have had neither the expertise nor the resources to custom-design systems. However, in the past ten years, there has been a revolution in low-cost, high performance microcomputers and intuitive and relatively low cost process control software. With the rapid development of microcomputer technology, numerous 'user-friendly' software and hardware systems are becoming available for control and monitoring of industrial processes. These software packages use object-oriented programming that allows even inexperienced programmers to create customized programs. In addition, standardized data acquisition components and systems, software drivers and communication software are available for several different computer platforms and over a wide range of costs.

Computer control and monitoring systems in aquaculture can be separated into two design strategies: 1) closed loop controllers, data logger systems or stand-alone programmable logic controller (PLC) systems or 2) centralized microcomputer based system (Figure 1 and 2). The first design strategy can also be expanded to a distributed process control system, where each of the stand-alone monitor/control units relays data to a central supervisory microcomputer. Examples of the stand-alone closed loop controllers are dissolved oxygen analyzers (YSI, Royce, BalancedAquaSystems, and Point Four Systems, Inc.) and temperature controllers (Cleveland Process Corp.). Each of these closed-loop controllers is normally equipped with both control relays and high/low alarm relays. In general, these units have limited data display capabilities and normally do not store data, but are equipped to transmit the data to a central, supervisory microcomputer. With stand-alone systems, individual sensors are easy to service and calibrate, since each has its own hardware and display unit. In addition, monitoring and control is performed at the lowest system level, which provides a high degree of overall system stability and robustness. If a failure occurs in the supervisory microcomputer, the stand-alone units will continue to monitor and control critical processes. If a failure occurs in the stand-alone system, the supervisory microcomputer can by comparing to previous measurement or measurements from other sensors to detect the abnormal conditions and alert the operator.

An example of such a system recently installed by the author was based on the duTec 'I/OPLEXER' remote input/output system. The I/OPLEXER is an industrial-grade data acquisition and control system, which communicates with a host computer through a serial communications link (RS-232, or RS-422/485). Controlled by a host computer, the I/OPLEXER is located near the sensors or stand-alone monitoring/control units. The system has a wide range of I/O modules, both analog and digital. At a recent installation, this basic system design monitored oxygen levels at four locations, temperature, three flow rates, pH, electrically actuated valve status (open/closed), aeration pressure and several level alarms in the production tank and sumps. The stand-alone monitoring unit directly controlled critical backup systems, such as oxygen, with alarm and additional backup provided by the central supervisory microcomputer. The control software used (GENESIS for Windows from Iconics), allowed for graphic display of system status, as well as graphic display of system parameters such as dissolved oxygen and temperature. In addition, the system logged data for trend analysis and alarm logging and displayed individual alarm response windows with detail response instructions. The system was relatively easy to install using existing outputs from each of the stand-alone monitors (dissolved oxygen, etc.) and the appropriate input module for the I/OPLEXER.

Other examples of interface hardware between the supervisory computer and the stand-alone modules include Campbell Scientific CR10X Measurement and Control System, Craig Ocean Systems, Inc., and Aqua Monitrol. Examples of other commercially available control system software include Intellution, LabView from National Instruments, and WonderWare from InTouch. Aquadyne has introduced a complete system designed to both monitor and control individual systems with a stand-alone system, AquGuard hardware networked to a centralized computer via

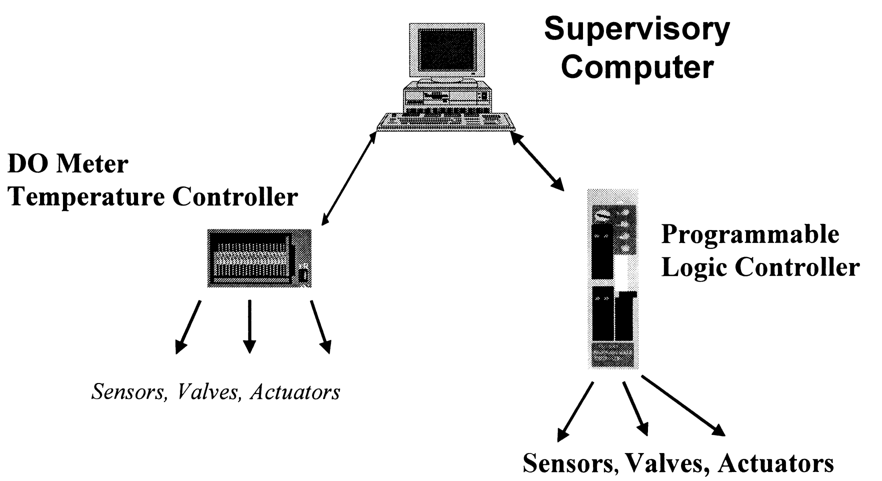

Figure 1. Stand-alone closed-loop controllers and programmable logic controller (PLC) systems

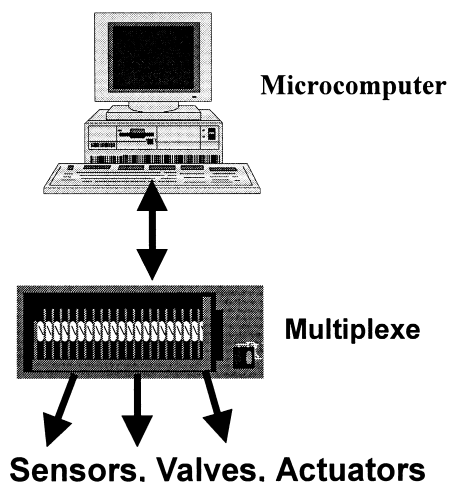

Figure 2. Centralized microcomputer based system.

AquaNet. Several companies also provide system design and installation services such as AquaTrak software and BalancedAquaSystems.

The second design strategy utilizes commercially available data acquisition boards, that are either located in existing expansion slots in the computer or communicated to it via a serial interface link. There is a wide selection of data acquisition boards available over a wide range of cost, performance and sophistication, including analog to digital (A/D) cards for monitoring voltages or currents from sensors, digital to analog (D/A) cards for outputting analog control voltages, and input/output cards (I/O) for monitoring and outputting digital control signals. They are easy to use, "just-plug-in", and come with a set of standard drivers and application software programs. Many types of sensors can be connected directly to these boards and most meters usually have some form of recorder output (0-5 V or 0-20 mA). In contrast to the distributed system, the microcomputer operates as the primary controller, monitoring and recording data and controlling alarm functions. These systems are not as inherently reliable as the distributed systems, but overall systems cost is less, since they are based on fewer and less expensive components.

A typical system installed at an aquaculture research center consisted of a single data acquisition card from National Instruments Corporation, AT-MIO-16X, with 16 single-ended or 8 differential analog input channels, two 16 bit analog output channels, eight digital I/O lines and three independent 16-bit counter/timers. In four separate research tanks, dissolved oxygen is monitored using OxyGuard probes inputted directly into the analog inputs, temperature with a thermistor probe, and water level, sump level, and backup oxygen monitored or controlled by the digital input/output line.

SYSTEM DESIGN AND MAINTENANCE

Listed below are some general suggestion about overall system design and maintenance:

System Design:

- choose sensors carefully, use the fewest possible, label everything and include expansion capability in all components.
- aquaculture facilities are now included under the National Electric Code, it may not be of concern to you, but it is to your insurance agent.
- mount sensors and equipment where they are visible and easily accessible for service and calibration.
- remember that water and electricity make for a fatal combination, so use low signal voltages (5 VDC, 12 VDC or 24 VDC or AC) to protect you and the fish.
- clearly label the sensor's armed and unarmed modes preferably with LED's at each station to show sensor status.

System Maintenance:

- have a well prepared maintenance manual accessible to the staff.
- maintain a weekly/monthly/yearly maintenance scheduling plan and files of major service records and equipment manuals.
- daily/weekly/monthly instrument check lists.
- regular (and some unannounced) system checks, including triggering of each sensor and checking operation of the automatic backup systems and phone dialer.
- staff training to handle routine alarms.
- staff familiarization with complete operating system, including water supply, aeration and emergency backup systems.

CONSTRUCTION HINTS

Probably the most important rule during design and construction is to keep it simple, known as the "KISS" principle. The other rule is to always assume that someone else will have to repair it, thus design notes, wiring diagrams, and labels are important. In addition, system components should be readily available from local or reliable sources. A "one-of-its-kind" is just that, and will soon become extinct. While designing and constructing, plan for expansion and leave room for additional systems or more "bells & whistles".

As much as possible, all materials used for system housing and hardware should be PVC, fiberglass or stainless steel to minimize corrosion. Water-resistant PVC junction boxes and fiberglass electrical cabinets, corrosion resistant and easy to drill holes into, are ideal housing to protect the electrical components. Include several vent holes to minimize heat build up in the cabinets. All external sensors should be low voltage, (i.e. 24 VAC or 24 VDC, ON-OFF), to minimize danger to operators and fish. Crimp style quick disconnect tab connectors on switches allow for easy construction and later modification. Solder joints should be covered with shrink-wrap tubing whenever possible. When buying individual components, look for extra options that may be useful in the future, such as extra alarm relays, voltage or current outputs and computer interfacing capabilities.

One simple trick to minimize the effects of aquaculture's harsh environment is to pressurize the control system housing using the aeration air supply. In this manner, relatively dry air is forced into the housing, preventing the high humidity and salt air from getting in. Alternatively, the step-down transformer in many of the systems provides a source of heat, thus preventing condensation from occurring.

For information on sources of equipment and supplies, see *Aquaculture Magazines Buyers Guide* or check out the Aquaculture Engineering Web Site at

REFERENCES

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Ebeling, J.M. 1995. Engineering design and construction details of distributed monitoring and control systems for aquaculture. In *Aquacultural Engineering and Waste Management*, NRAES-90. pgs. 1-22, Northeast Regional Aquaculture Engineering Service, Ithaca, NY.

Lee, P.G. 1995. A review of automated control systems for aquaculture and design criteria for their implementation. *Aquaculture Engineering*, 14:205-227.

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Tsukuda, S.M., J.M. Ebeling, and B.J. Watten. 1998. Application of industrial monitoring and control for an experimental carbon dioxide stripper in a recirculating aquaculture system. In *Proceedings of the Second International Conference on Recirculating Aquaculture*, July 16-19. pgs. 371-372. Virginia Tech., VA.

James M. Ebeling is a Ph.D. graduate student in Biological Resources Engineering at the University of Maryland College Park. His background includes developing monitoring and control systems for pond culture at the Maricultural Research and Training Center at the University of Hawaii, "The Fish Barn" at North Carolina State University and as a Research and Extension Associate at the Piketon Research and Extension Center at Ohio State University.

Sources of Equipment

Aquadyne Computer Corp., 619-569-2082	http://www.aquadyne.com
Aquatic Eco-Systems, Inc., 800-422-3939	http://www.aquatic-eco.com
AquaTrak Systems, 800-655-1047	
BalancedAquaSystems, 909-652-2612	
Campbell Scientific, Inc., 435-753-2342	http://www.campbell.com
Cleveland Process Corp., 800-241-0412	
Craig Ocean Systems, Inc., 408-336-3403	http://www.cos-inc.com/
ICONICS, 508-543-8600	http://www.iconics.com
Intellution, 800-526-3486	http://www.intellution.com
National Instruments, 512-794-0100	http://www.natinst.com
Phonetics, Inc., 610-558-2700	http://www.sensaphone.com
Point Four Systems, Inc., 604-936-9936	http://www.pointfour.com
Royce Instrument Corp., 504-254-8888	http://royceinst.com
Wonderware, 714-727-3200	http://wonderware.com
W.W. Grainger, Inc.	http://www.grainger.com
YSI, Inc., 800-765-4974	http://www.ysi.com

UPCOMING MEETINGS

World Aquaculture '99

The Aquacultural Engineering Society will sponsor two days of technical sessions and workshops at the Annual Meeting of the World Aquaculture Society in Sydney Australia scheduled for April 26 - May 2, 1999. The first day will include a Presidents Session that will feature 4 invited speakers from around the globe highlighting advancements in aquaculture engineering in Europe, Latin America, Australia, and Asia. Also on the first day will be a producer oriented 1/2 day workshop focussing on water reuse technology in pond systems. During the second day, the AES will sponsor a technical session to include 10 contributed scientific paper presentations and another workshop focussing of water reuse technology in tank systems. The programs follow:

DAY 1 (April 27, 1999)

Advances in Aquaculture Engineering Around the Globe
Moderator: Dr. Tom Losordo, President AES

10:50 - 11:30	Dr. John Patterson, *Aquacultural Engineering in Australia*
11:30 - 12:10	Dr. James Muir, *Advances in Aquaculture Engineering in Europe*
12:10 - 12:30	Questions and Discussion
	Lunch
13:30 - 14:10	Mr. German E. Merino *Aquacultural Engineering in Latin America*
14:10 - 14:50	Dr. Rolando Platon *Aquacultural Engineering in Southeast Asia*
14:50 - 15:10	Questions and Discussion

Aquacultural Engineering Society — Workshop I

15:50 - 17:50	Dr. David Brune, Dr. Tom Schwedler, Dr. John Collier *Water Reuse Technology in Freshwater Ponds*

DAY 2 (April 28, 1999)

Aquaculture Engineering Society — Contributed Papers Session
Moderator: Dr. Dave Brune, Past-President AES

8:30 - 8:50	Eric Peterson and Paul Muir
8:50 - 9:10	Eric Wolanski and Lindsay Trott
9:10 - 9:30	Jose Chavez
9:30 - 9:50	Christain Balnath, Robert Romaire and Harald Rosenthal
9:50 - 10:10	Shulin Chen, Broods Saucier, Songming Zhu and James Durfey
10:10 - 10:50	Break

Moderator: Dr. Eric Peterson, Member, AES Program Committee

10:50 - 11:10	When Fang and Chia-Meng Chang
11:10 - 11:30	Kenneth McDill, Doug Minchew, Walter Gandy and Travis Burke
11:30 - 11:50	Walter Zachritz, John Mazorra and Adrian Hanson
11:50 - 12:10	Yngve Ulgenes and Bjornar Eikebrokk
12:10 - 12:30	Yoram Avnimelech
12:10 - 12:30	Lunch

Aquacultural Engineering Society — Workshop II

13:30 - 15:10	*Recirculating Tank Systems - Engineering Basics* Thomas Losordo and James Muir
15:50 - 17:30	*Recirculating Tank Systems - Recent Advancements and Applications* Thomas Losordo and James Muir

Cornell 5th Annual Aquaculture Water Reuse Systems Short Course

Cornell University will be offering its 5th Annual Aquaculture Water Reuse Systems Short Course from June 22 - June 26, 1999 (4.5 days). This 4 and _ day short course (a Saturday tour ends at noon) is intended to give a thorough coverage of the design, operation, and management of water reuse systems for finfish. Limited coverage will be given to engineering economics. The course will be taught by members of the Cornell Aquaculture Program, led by Dr. Michael Timmons, and other outside experts including Dr. Steven Summerfelt (Freshwater Institute), Mr. Brian Vinci (Freshwater Institute) and Mr. James Ebeling (University of Maryland). A combination of "hands on" laboratories and classroom presentations will be offered at the Cornell Animal Science and Teaching Center (ASTARC), Harford, NY and the main campus of Cornell University, Ithaca, NY. ASTARC is the site of Cornell's intensive water reuse production facility. This facility has a variety of tank sizes and nitrification systems in operation, which are currently being used for breeding, hatching, and grow-out of tilapia, as well as a complete wet laboratory for analysis. At the conclusion of the workshop, individuals should be able to design their own water reuse systems and have a fundamental knowledge of the principles influencing design decisions. The following topics will be addressed:

System carrying capacity (oxygen, solids, ammonia, carbon dioxide, and constraints)
Space and volume requirements
Flow requirements
Fluid mechanics, pressure losses
Nitrification principles and bio filter design
Water chemistry
Monitoring and control systems
Group design projects
Tour of local aquaculture facilities

The cost of the short course is $650. The fee covers course materials, travel from any of the housing options to the site, daily breakfasts, lunches and banquet dinner. Enrollment is limited and a $200 deposit is required by June 1, 1999. To enroll in the course or for more information contact Brenda Snowberger (Agricultural & Biological Engineering, 312 Riley-Robb Hall, Ithaca, NY 14853, Phone: 607-255-2495, Fax: 607-255-4080, E-mail: bls19@cornell.edu) or visit our website at http://pomona.aben.cornell.edu/shortcourse.

Where Are We Today?
An Issues Forum for Aquacultural Engineers

November 4-5, 1999 • Raleigh, North Carolina, USA

Prologue

Every once in a while we, the members of the Aquacultural Engineering Society, need to gather together and reflect upon the advances that have been made in the arts and sciences of aquacultural engineering and the important issues facing us. Without a doubt, re-circulation, or is it recirculation, has taken much of our time and attention. The advances we have made in recirculating systems, and there are many, not only did not diminish the problem they seemed to have added to its dimension.

At the beginning, we seemed to know what biofilter means. Do we still think so? Bacteria certainly can remove nitrogenous substances from an aquaculture system, but so do algae and vegetables. So here come the Photo-Bioreactor Systems. Are those terms befitting the bioengineering direction many of us are moving toward, or are these terms an indication that we are deserting our farming background?

The marriage of Hydroponics and Aquaculture seems to be made in Heaven, or is it? If it is, why haven't we seen more of it? Vegetables require high nutrient levels, but do they really? Can vegetables thrive in low nutrient environments if the water velocity in the root zone is increased?

Then there are the growth vessels, which is a fancy way to say tanks, ponds and raceways. Do we know how to design them? Should ponds be big and elongated, or small and round? If they are to be small and round, do we need ponds at all?

Many of us think we can argue on both sides of these issues, and here is an opportunity for you to do exactly that.

On November 4-5, 1999, come and join your fellow engineers for two days of serious discussions (designs, formula, and data), laughing, and beer (wine for more cultured persons, and rum for those with exotic tastes, uh?). The AES Issues Forum will be hosted at North Carolina State University's Jane S. McKimmon Conference Center for Extension and Continuing Education in Raleigh, North Carolina, USA. On November 6, 1999, optional tours will be run at the Carolina Power & Light Fish Barn at North Carolina State University and possibly at a commercial recirculating farm.

Thomas Losordo is the local host (Tel: 919- 515-7587; Fax: 919-515-5110; and Jaw-Kai Wang, and David Brune are the Program Chairs for this Issues Forum.

There will be a registration fee of only $100 for AES Members (registration will be $185 for non-AES members), which includes two lunches, dinners, a wine and beer social on November 4th, and coffee/soft drinks during the breaks. E-mail Steven Summerfelt or fax him (304-870-2208) and tell him you are coming, what issues most interest you, and what kind of beer/wine/soda you like to drink. Even better, use the AES Issues Forum registration information on page 12 of this Newsletter. Registration will be limited to 135 and your registration material must be received by October 20, 1999.

Preliminary Topics:

1. Bacteria, algal, and plant biofilter systems
2. Tanks, ponds, and extensive systems
3. Water replacement in recirculating systems
4. Intergrated aquaculture systems and component design

Logistics

LOCATION:
The Jane S. McKimmon Conference Center
North Carolina State University
1101 Gorman Street
Raleigh, NC 27695-7401 USA

DATES:
Issues Forum: November 4-5, 1999
Optional Tours: November 6, 1999
Carolina Power & Light Fish Barn at North Carolina State University Commercial Recirculating Production Facility

TRANSPORTATION:
Raleigh/Durham International Airport (airport code RDU). RDU is served by American, Delta, Northwest, United, Air Tran, US Airways, Midway and Southwest Airlines.

Free shuttles are available from RDU to the Ramada Inn and the Velvet Cloak Inn.

LODGING:
Ramada Inn/Blue Ridge
1520 Blue Ridge Road
Raleigh, NC 27607
Telephone: (919) 832-4100

The Ramada Inn is the preferred hotel for the conference (free transportation to the conference site). Conference Room Rate: $69.00/night.

Velvet Cloak Inn
1505 Hillsborough Street
Raleigh, NC 27605
Telephone: (919) 818-0333

SOCIAL AGENDA:
Break service, lunch and dinner will be provided on November 4th and 5th as part of the registration package. On November 4th, we will gather before dinner for a social hour; beer and wine are included in the registration

CONTACTS:
Local Host: Thomas Losordo, tlosordo@unity.ncsu.edu
Tel: (919) 515-7587
Fax: (919) 515-5110

Forum Program: Jaw-Kai Wang,
jawkai@hawaii.edu
David Brune,
debrune@clemson.edu

REGISTRATION

Registration will be limited to 135. Deadline for registration is October 20, 1999. Registation will not be available at the door.

	AES Members	Non-Member
Conference registration	$100 per person	$175* per person
Tours on November 6	TBA	TBA

*Non-member registration includes membership in the AES for one year, which includes a years subscription to Elsevier's journal *Aquacultural Engineering* and the *AES News*.

Name Badge Information (As you want your badge to read).

Name ______________________________

Company/Institution______________________________

City ______________ State/Province ______________ Country ______________

Contact Information.

Address ______________________________

City ____________ State/Prov. ____________ Zip Code ________ Country ____________

Phone ______________________ Fax ______________________

E-mail ______________________________

Payment Method.

Registration must be paid in U.S. Dollars (Allow 2-3 weeks for processing).

☐ Check (Payable to: Aquacultural Engineering Society) ☐ Visa ☐ Mastercard

Card # ______________________Expiration Date ______________

Exact Spelling of Name on Card ______________________________

Please send registration information and payment to:

Steven Summerfelt
AES Secretary/Treasurer
c/o Freshwater Institute
P.O. Box 1889
Shepherdstown, WV 25443
Tel: 304-876-2815 Fax: 304-870-2208
Email: s.summerfelt@freshwaterinstitute.org

NEWS FROM ELSEVIER SCIENTIFIC PUBLISHERS

Aquacultural Engineering Journal Update Sheet

PUBLICATION SCHEDULE
1997: Volumes 16 - 17 (2 volumes)
1998: Volumes 18 - 19 (2 Volumes)
Present publication status: Volume 19/4 was published in March 1999.

Number of papers received in 1997: 62
1998: 56.

Average time-span from acceptance to publication in
1996: 39 weeks
1997: 30 weeks.

Rejection rate in 1996: 30 %
1997: 25%.

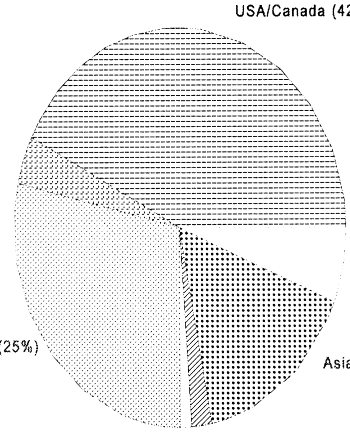
ORIGIN Of PUBLISHED ARTICLES (excluding special issues)

	1996	1997	1998
North America	32%	50%	47%
Central+South America	9%	7%	9%
Western Europe	44%	20%	23%
Eastern Europe	0%	0%	0%
Asia	12%	17%	14%
Africa	0%	3%	0%
Australia/N. Zealand	3%	3%	7%
Total Number:	34	30	43

IMPACT FACTOR

	1993	1994	1995	1996	1997
Category: Engineering:					
Impact factor	0.293	0.410	0.465	0.708	0.441
Ranking:	19	13	14	4	20
Category: Fisheries:					
Ranking:	17	12	15	15	22

SUBSCRIPTIONS
Geographical breakdown of subscribers:No. of AES member subscriptions: (1998): 220



EDITORIAL BOARD CHANGES
Members recently appointed to the *Aquacultural Engineering* (AQUE) Editorial Board:

- K. A. Rusch, Baton Rouge, LA, USA
- A. M. Schuur, Ft. Pierce, FL, USA
- D. Weaver, Huntington Beach, CA, USA

FORTHCOMING SPECIAL ISSUES
Developments in Recirculation System Technology, guest-editor R. Piedrahita
Computer Tools for Siting, Designing and Managing Aquaculture Facilities, guest-editor Dr Ernst

CONTENTS DIRECT
ContentsDirect, the free e-mail alerting service, delivers the table of contents for AQUE directly to the PC of interested scientists, prior to publication. The quickest way to register for ContentsDirect is via the Internet at: http://www.elsevier.nl/locate/ContentsDirect.

Information about AQUE is also available on the World Wide Web at the following addresses: http://elsevier.nl/locate/aquaeng or http://www.elsevier.com/locate/aquaeng.

If you don't have access to the Internet you can register for this service by sending an e-mail message to cdsubs@elsevier.co.uk - specifying the title of the publication you wish to register for.

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Elsevier Science offers a new service called OASIS which stands for On line Article Status Information System. With this service authors of articles which are currently in production at Elsevier can obtain the following information on the status of their article:

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Visit Elsevier's web page at www.elseview.nl

From the *Aquacultural Engineering* Editor-in-Chief

Dear Colleague,

As editor of *Aquacultural Engineering*, I am pleased to send you this brochure on the journal, and to invite you to submit your research in this rapidly developing field. The journal is peer-reviewed, international, and provides a forum for the publication of articles on all aspects of unit process design, process control, bioengineering, and full-scale operations.

Aquacultural Engineering has established a strong reputation with a good position in the *SCI Journal Citation Reports*. Moreover, it is indexed in main bibliographic databases such as *Current Contents* and *Aquatic Sciences & Fisheries Abstracts*. Papers are submitted from all over the world, both from academic as well as the consulting engineering and commercial sections.

In addition to Research Papers, Short Communications and Review Articles, we will continue to publish Special Issues dedicated to topics of current interest. If you have a question about submission of a given manuscript to the journal, you are encouraged to e-mail or fax the outline of the manuscript to me prior to formal submission.

With its comprehensive, timely and unique coverage, *Aquacultural Engineering* is the journal you need to stay informed on all the latest advances and developments in aquacultural engineering.

We are dedicated to the further development of *Aquacultural Engineering* within a dynamic and challenging environment, and we'll look for new opportunities to strengthen its position.

We will continue to guarantee rapid and high quality peer-review of your submitted manuscript, followed by timely publication. This guarantees that your results and ideas will reach the scientific community without delay.

Aquacultural Engineering is the official journal of the Aquacultural Engineering Society. Membership in this society allows you to purchase the journal at a significantly reduced rate.

I look forward to reading your paper.

John Colt

John Colt, Editor

P.S. You can find out more about submitting papers to *Aquacultural Engineering* by checking the Elsevier Science homepage: www.elsevier.nl/locate/aquaeng. For more information on the Aquacultural Engineering Society, visit the AES web page at: www.cals.cornell.edu/dept/aben/aes/.

AQUACULTURAL ENGINEERING POSITION

Location: Department of Biological and Agricultural Engineering
Company: Louisiana State University
Closing: April 30, 1999 or until a suitable applicant is found.
Salary: Commensurate with training and experience.

Qualifications

Applicant must have earned a Ph.D. in aquacultural engineering, biological engineering, agricultural engineering, or related engineering discipline with emphasis, course work, and/or experience in aquacultural engineering.

Description

RANK: Assistant/Associate Professor

APPOINTMENT: Academic, tenure-track position, approximately 66% research in the Louisiana Agricultural Experiment Station and 34% teaching in the LSU College of Agriculture.

DUTIES AND RESPONSIBILITIES: The Department of Biological and Agricultural Engineering, Baton Rouge, Louisiana is seeking a faculty member to develop and lead a research and teaching program in Aquacultural Engineering. The faculty member should be innovative in research approaches and willing to participate in an interdisciplinary research environment to provide expertise in Aquacultural Engineering to address problems of the aquaculture industry in the state. Research projects will be in Aquacultural Engineering, including systems for the culture, harvesting, grading, processing, and by-products utilization of Louisiana's aquacultural species. Teaching duties will include undergraduate and graduate courses in Biological Engineering and Aquacultural Engineering. The faculty member will direct graduate students and provide expertise in this area of advanced study.

Contact

Submit letter of application, resume, transcript and a list of three references to: Dr. Lalit R. Verma, Professor and Head, Biological and Agricultural Engineering Department, Louisiana State University, Baton Rouge, Louisiana 70803-4505 E-mail: lverma@gumbo.bae.lsu.edu

AES Sponsors

The AES is looking for sponsors within the aquaculture industry to support the increased cost of producing the *AES News*. The sponsors listed below have donated generously to support the AES. For this donation, the AES will be inserting a one-page product literature sheet in one of the newsletter mailings, and list the vendor as an AES supporter in four consecutive newsletters. Please contact one of the *AES News* Co-Editors if you would like to be a sponsor.

Aquatic Eco-Systems, Inc.
1767 Benbow Court, Apopka, FL 32703
ph: (407) 886-3939
fax: (407) 886-6787
e-mail: aes@aquaticeco.com
web site: http://www.aquaticeco.com

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P.O. Box 66125, Baton Rouge, LA 70896
ph: (225) 755-0026
fax: (225) 755-0995
e-mail: wmtech@mindspring.com
web site: www.w-m-t.com

Aquaculture Systems Technologies, LLC.
P.O. Box 15827, New Orleans, LA 70175
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e-mail: AQUASYS@BeadFilters.com
web site: www.BeadFilters.com

P. R. A. Manufacturing Ltd.
P.O. Box 774, Station A, Nanaimo, British Columbia V9R 5M2 CANADA
ph: (250) 754-4844
fax: (250) 754-9848
e-mail: info@pramfg.com
web site: www.pramfg.com

Aquaneering, Inc.
8280 Clairemont Mesa Blvd., Suite 117, San Diego, CA 92111-1708 USA
ph: (619) 541-2028
fax: (619) 541-2048
e-mail: markf@aquaneer.com
web site: WWW.AQUANEER.COM

AES Newsletter

The *AES News* is printed quarterly by the Aquacultural Engineering Society. You can receive the *AES News* by joining the Aquacultural Engineering Society. If you would like to discuss the contents of the *News*, or, if you would like to contribute information to the *News*, please contact either of the two Co-Editors:

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Permission to quote from or reproduce articles in this publication may be obtained by contacting either Co-Editor of the *AES News*.

The **Aquacultural Engineering Society** was founded in 1993 to provide a forum for addressing engineering problems related to aquaculture. Its membership is open to engineers and non-engineers engaged in the culture, processing, and/or distribution of aquatic organisms or their by-products. The AES serves as an authoritative source of engineering information and support to the aquaculture industry. Working with other aquacultural groups and societies, the AES brings people together to discuss new ideas and technologies of benefit to the aquacultural community as a whole.

AES Members receive a one-year subscription to the journal *Aquacultural Engineering*, updated membership directories, and the *AES News*.

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Five Reasons to Become an AES Member

1. Build your knowledge

By receiving 8 issues per year of the journal *Aquacultural Engineering*, you will be able to increase your knowledge of what's going on in the design and development of effective aquacultural systems for marine and freshwater facilities. You will also receive the *AES News* and ordering information on past and future AES publications.

2. Build a professional network

By attending the numerous workshops and conferences sponsored by AES, you can stay abreast of current aquacultural engineering applications and solutions, and expand your network of colleagues and professional contacts within the industry. The *AES News* will keep you informed about upcoming aquacultural events.

3. Build your profession

By being a part of an international organization working to improve, foster, and enhance development of the aquacultural engineering profession, you as an individual will benefit from the efforts of the membership as a whole.

4. Build your credibility

By joining a growing international society, you will be demonstrating your commitment to the industry and your proactive stance towards perpetuating its growth.

5. Build your expertise

By participating in AES scheduled conferences and events where the latest technologies are presented and discussed, you will increase your knowledge base and boost your professional development.

For more information on the AES, visit the AES web page at: http://www.cals.cornell.edu/dept/aben/aes/

To join the AES, please fill out the following information and send with payment to: Steve Summerfelt, c/o Freshwater Institute, P. O. Box 1746, Shepherdstown, WV, 25443, USA (fax: 304-870-2208). Make cheques payable to the Aquacultural Engineering Society. You do not have to provide education information to become a member.

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