Aquacultural Engineering Society News

AES News, Fall 1998, Vol. 1, No. 3

'98 Aquaculture Europe Highlights Recirculating Systems

The European Aquaculture Society's (EAS) Annual Conference took place in Bordeaux, France, October 7-10, 1998. The Conference focus was "Aquaculture and Water: Fish Culture, Shellfish Culture, and Water Usage." The 3-day conference consisted of oral and poster papers, selected and case study papers, poster sessions, and technical excursions. Workshops were also offered on recirculation technology, larval rearing in fish and shellfish, and co-management of production basins in fish and shellfish culture.

The AES co-sponsored the special "Technical Workshop on Recirculation Systems" that complemented the Conference's scientific session Developments in Recirculation Systems." Raul Piedrahita (University of California, USA) and Johan Verreth (Wageningen Agriculture University, The Netherlands) organized and chaired the Conference session "Developments in Recirculation Systems". Piedrahita and Verreth were joined by Jean Paul Blancheton (IFREMER, France) in organizing and chairing the "Technical Workshop on Recirculation Systems". The conference session included presentations from international experts representing several countries: the Netherlands (E. Eding), USA (T. Losordo, R. Malone, S. Summerfelt), France (J. P. Blancheton, S. Helgason, F. Lefebvre), Israel (J. van Rijn, Y. Avnimelech), Germany (A. Boley), Norway (S. Cripps), Iceland, and the United Kingdom (K. Lorenzen). Selected speakers were also invited to submit their presentations as papers for publication consideration in a special issue of Elsevier's journal Aquacultural Engineering. Accepted papers should be published in 1999 or 2000.

The "Recirculating System Workshop" included presentations by producers of recirculation systems. Speakers presented their philosophy of design and illustrated it with details on a hypothetical farm. Five commercial recirculating system suppliers participated in the session:

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Letter From Your President

We're just a few weeks away from the Aquaculture America '99 meetings to be held in Tampa Florida, Jan 27-30, 1999. This issue of AES news gives the details of the 2 days of AES sessions (see page XX). The Aquacultural Engineering Society will hold two workshop on the first day; the five morning papers dealing with engineering fundamentals in pond and recirculating culture systems; the afternoon papers will address advanced issues of gas transfer and aeration. AES day two contains 13 contributed papers dealing with a wide variety of topics. In the past, our workshops have been very popular, attracting a large audience. We plan to offer summaries of the workshop presentations at the AES booth, located in the trade show. Tampa will also serve as the location for our annual business and general membership meetings. At the conclusion of these meetings AES president-elect, Dr. Tom Losordo, will begin his term; so, in the next issue these words of wisdom will be coming from Dr. Tom! I look forward to seeing everyone in Tampa.

Dave Brune,
AES President

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 1998 volumes) of the journal *Aquacultural Engineering, the AES News,* and the AES Member Directory.

Aquacultural Waste Management

By Shulin Chen, Washington State University

INTRODUCTION

As the aquacultural industry grows and environmental regulations get more stringent, waste management has become a major task for aquaculture farm managers. A waste management strategy is now considered critical for maintaining the legality, profitability and sustainability of an aquaculture facility.

As in other animal operations, the issue of waste becomes significant when the fish biomass is intensive and supplemental feed is used. Waste from an aquaculture facility is typically produced as either effluent or sludge. Effluent is exchanged water with dilute pollutant concentrations, while sludge contains more concentrated particulate matter. Typical waste components from an aquaculture discharge include organic feces and nutrients. If a significant amount of it is discharged directly into streams or lakes, aquaculture waste will cause adverse environmental impacts: The decay of the organics can reduce dissolved oxygen concentration in the water bodies; the excess nitrogen and phosphorous can stimulate algal bloom and create nuisance conditions; the particulate matters can deposit on the bottom of the receiving water, either physically altering the habitat condition of the water body or chemically causing local depletion of dissolved oxygen.

Waste discharge from aquaculture operations is governed by The National Pollution Discharge Elimination System (NPDES) that is used by the U.S. Environmental Protection Agency (EPA) to regulate various pollutants from point sources. Discharge of pollutants to receiving waters from aquacultural production facilities, except as provided in the permit, is a violation of the Clean Water Act, and may be subject to enforcement action by EPA. NPDES permits are required for fish hatcheries, fish farms, or other facilities that raise aquatic animals under the following conditions:

(1) Cold water fish species or other cold water aquatic animals in ponds, raceways, or similar structures that discharge at least 30 days per year, produce more than 20,000 pounds of aquatic animals per year, or receive more than 5,000 pounds of food during the month of maximum feeding.

(2) Warm water fish species or other warm water aquatic animals in ponds, raceways, or similar structures that discharge at least 30 days per year. This does not include closed ponds which discharge only during period of excess run-off or warm water facilities which produce less than 100,000 pounds of aquatic animals per year.

(3) Facilities determined on a case-by-case basis by the permitting authority to be significant contributors of pollution to waters of the United States.

In most cases, aquaculture facilities are not given permits unless they have a waste management plan that meets the environmental regulations. Minimizing the environmental impact of nutrients and solids produced from aquacultural facilities is the primary objective of most aquacultural waste management plans. In fact, the aquaculture industry has been making constant efforts, from several different avenues, to address both pollution reduction and waste management, and has demonstrated some best management practices (BMPs). Examples of BMPs include phosphorus reduction through the use of low phosphorous feed and improving phosphorus digestion efficiency, effluent minimization through the adoption of recirculating systems, and treatment of effluent through solids separation. A waste management plan should incorporate these practices as much as possible.

Although waste management strategies are generally different for different culture systems, solids removal and sludge management are often the most important component because the majority of the pollutants are associated with the particles in the sludge. Thus, this paper will focus on aquacultural sludge management, including sludge production, characterization, treatment, and disposal.

WASTE PRODUCTION

Waste Excretion

The first step in waste management is to estimate the quantity of waste excreted by fish in a culture system. Waste excretion rate is typically related to feeding rate since virtually all the wastes generated from an intensive aquacultural system originate from the feed. Assuming a typical feed conversion ratio of 1 to 2 and neglecting the impact of uneaten food, 80% of feed (on a dry mass basis) input to an aquacultural system will eventually become waste as fish excretion products (Hopkins and Manci, 1989), including carbon dioxide, ammonia, and feces. Relating excretion rate to feeding rate is also convenient since feeding rate is a key operational parameter in aquaculture operations.

The amount of feces excreted by fish is typically reported as total suspended solids (TSS), which theoretically include all particles greater than 2 microns in size. TSS excretion rates for trout and catfish have been a topic of many studies. The direct TSS excretion rate varied from report to report, ranging from 0.30 to 0.52 kg per kg-feed for trout, and from 0.18 to 0.69 kg per kg-feed for catfish. Clearly, TSS excretion rate will vary with species, temperature, and feeding rates. However, values in the range of 0.2 to 0.4 kg-TSS per kg-feed appear to be typical.

The second parameter for measuring excretion is biochemical oxygen demand (BOD5), representing the amount of oxygen consumed by the organics in the waste that biodegrade within 5 days under standard conditions (20°C). BOD5 excretion rate is also generally expressed as a ratio to the feeding rate. BOD5 excretion rate varies more widely and is typically lower than TSS rate. Of the BOD5 excreted, over half is in particulate form and the rest is dissolved in water.

One of the major factors that contribute to the differences in reported excretion values is the amount of uneaten feed that ends up as feces. Under laboratory conditions, the amount of uneaten feed is usually minimized, whereas under commercial conditions the amount of unconsumed feed is less controllable. Consequently, the excretion rates obtained under laboratory conditions are typically lower than those obtained under large-scale culture conditions.

Waste Production as Sludge

The amount of solids and the associated sludge volume are two major factors in aquacultural waste management. The solids mass production rate is determined by the waste excretion rate of the fish within the system, as well as by the system's internal waste treatment capability. The volume of sludge generated, on the other hand, is controlled not only by the amount of solids produced, but also by the degree to which the TSS are concentrated in the sludge stream. When solids are removed from a system either through backwashing a filter or cleaning a sedimentation tank, the resultant sludge is usually still relatively dilute, and the solids content is likely below 1%.

Because aquatic animals are very efficient at feed conversion, fish culture produces the least amount of waste, compared with large land animals, for a unit weight gain. However, if daily waste generation is considered on a live weight basis, the amount of waste produced by fish is comparable to that of other animals, but with a much higher sludge volume. Table I shows a comparison in which a feeding rate of 2% of body weight per day was assumed for a catfish system (Chen et al., 1997).

Table 1. Waste generation (/day/1000kg-LW) comparison between recirculating catfish systems and other commercial animal operations.

Animals	Fish	Beef Cattle	Dairy Cows	Poultry	Swine
BOD (kg)	0.8-1.3	1.6	1.4	3.4	3.1
Solids (kg)	3.9-6.3	9.5	7.9	14	8.9
TKN (kg)	0.2-0.32	0.32	0.51	0.74	0.51
Sludge Volume (liter)	65-630	30	51	37	76

CHARACTERIZATION OF AQUACULTURAL WASTES

Information on sludge properties is also critical for aquacultural waste management. For municipal sludge and other agricultural sludge such as livestock and poultry wastes, the essential data are generally well documented. Although less research was conducted on aquaculture sludge, some preliminary data are currently available.

Sludge Composition

Aquacultural sludge can be characterized both by the concentration of waste constituents or by the ratios of given constituents to total solids (TS) in the sludge. TS concentration in aquacultural sludge is mainly from TSS. For example, the BOD5/TS ratio is a measure of the degree of sludge stabilization. A high BOD5 /TS ratio implies a sludge that will rapidly decay and potentially cause oxygen depletion and odor problems if not properly managed. Similarly, the nutrient content of the sludge can be described by total nitrogen (TKN) and total phosphorus (TP) to TS ratio. Higher ratios represent better fertilizer values or strong pollution potential. The characteristics of the aquacultural sludge from a recirculating system using a plastic beads filter are illustrated in Table 2, with reference to domestic sludge.

Table 2. The chemical compositions of aquacultural sludge.

	Aquacultural Sludge[a]			Domestic Sludge[b]	
Parameter	Range	Mean	deviation	Range	Typical
TS (%)	1.4 -2.6	1.8	0.35	2.0 -8.0	5.0
BOD5 (mg/L)	1588 -3867	2756	212	2000 -30000	6000
TKN (N, % of TS	3.7 - 4.7	4.0	0.5	1.5 -4	2.5
TP (P, % of TS	0.6 -2.6	1.3	0.7	0.4 -1.2	0.7
pH	6.0 -7.2	6.7	0.4	5.0-8.0	6.0

a: Ning, 1996

b: Data from Metcalf and Eddy Inc. (1991)

Compared with typical municipal sludge, aquacultural sludge has lower solid and BOD5 concentrations. Of the solids contained in the aquacultural sludge, more than 80% are volatile, 20% higher than those in municipal sludge. Aquacultural sludge also has higher nitrogen and phosphorus contents. As shown in Table 2, the average TKN content of the aquacultural sludge was 4.0% of the dry solid mass, whereas the typical value for municipal sludge is only 2.6%. The average value of TP was 1.3% of the dry solid mass, while the typical municipal sludge contains only 0.7%. Olson (1991) found that fish wastes contain a higher percentage of nitrogen than cattle, pig and sheep wastes. The high TP and TKN contents in the fish sludge originate from the feed; most fish feeds contain 7.2% to 7.7% of nitrogen by weight. Of the nitrogen in these feeds, 67% to 75% will be lost to the aquatic environment. The phosphorus content of the commercial fish diet ranges from 1.2% to 2.5%, with as much as 80% being lost to the aquatic environment (Iwama, 1991).

Physical Characteristics

Major physical sludge characteristics that affect the design of a treatment system include particle settling velocity, density, and size distribution. Ning (1996) observed that the solids particles in aquacultural sludge from a bead filter settled out fairly quickly with an average zone settling velocity of 1.37*10-3 m/s (8 cm/min). The wet density of the sludge was measured as 1.004 g/ml, which is close to the typical value of a municipal sludge. The particle size distribution of the aquacultural sludge showed that particles less than 60 microns and greater than 1000 microns accounted for 15% and 17 % of the total dry weight, while particles ranging from 60 to 105, 105 to 500, and 500 to 1000 microns represented 8%, 29%, and 31%, respectively.

Biochemical characteristics

One of the major biochemical characteristics of sludge is its decay rate constant, which represents how fast the waste material decays under a given condition. A laboratory study (Ning, 1996) found that oxygen availability and temperature had significant impacts upon decay rate constants. From 10 to 30°C, the anaerobic decay rate constants of BOD5 varied from 0.004/d to 0.037/d. For the same temperature range, the aerobic decay rate constants varied from 0.188/d to 0.329/d. The impact of temperature on digestion rates was more significant for anaerobic digestions than for aerobic digestions.

The results also show that aerobic digestions were much more efficient than anaerobic digestions; the respective reaction rates for aerobic digestions were,

(Continued on next page)

on average, approximately 10 times higher than anaerobic rates.

It was also found that aquacultural sludge had digestion rate constants comparable to domestic sludge. For example, the maximum aerobic digestion rate constant of BOD5 for aquacultural sludge at 20°C was 0.14 to 0.32/d, whereas the reported value for municipal sludge was 0.05 to 0.3/d (Metcalf and Eddy, 1991).

TREATMENT AND DISPOSAL OF AQUACULTURE WASTES

Treatment and ultimate disposal are the two major steps in aquacultural waste management. Before the final disposal, two treatment processes, thickening and stabilization, may be necessary for some applications.

Gravity Thickening

The purpose of thickening is to increase solids content. In virtually all applications, it is always desirable to raise solids concentrations to a higher level to improve the economics of treatment and disposal. Clarification, often in settling tanks or ponds, is a common thickening process. When the sediments are removed from the settling unit, solids concentrations are usually at 2 to 5%.

Sludge Storage and Stabilization

A storage or stabilization process is necessary in environmentally sensitive areas where waste application on land is limited to certain times of the year and where offensive odors need to be minimized. There are typically two major benefits related to sludge storage and stabilization: volume reduction and organics decay. Stabilization processes can reduce sludge volumes by 50 - 75% (Reynolds, 1982) and provide for complete oxidation of readily degraded organics, resulting in a sludge that is unoffensive in nature. Stabilized sludges pose few problems when disposed through land application or landfilling.

Lagoons are the most feasible technology for stabilizing aquacultural sludge. Anaerobic lagoons have been used to treat waste discharges from all phases of the vast agricultural industry, and have also been considered suitable treatment processes for aquacultural wastes. In an anaerobic lagoon, the organic loading is so high that no appreciable oxygen concentration exists. Sludge introduced into the lagoon ranges from that containing relatively light solids concentrations (approximately 0.1% solids) to slurries containing just enough water to transport the solids into the lagoon. Anaerobic lagoons function successfully over a wide solids-loading range with little maintenance. The major parameters used for anaerobic lagoon design are volatile suspended solids (VSS) or BOD5 loading.

Whenever possible, a two-stage lagoon system should be used for sludge stabilization. A two-stage lagoon system is typically designed in such a way that the first stage is anaerobic, and the second stage is facultative. The main objective of an anaerobic lagoon is BOD reduction though organic decay, while the main objective of a facultative lagoon is nitrogen reduction, as well as additional BOD removal. Typical effluent quality from a facultative lagoon is not adequate for direct discharge, but is more appropriate for irrigation.

Sludge Disposal

Currently, the aquacultural sludge disposal process most often used is direct land application. Application methods include using sprinklers and tank trucks. Because high-rate land application of animal manure as a waste has been proven to cause adverse environmental impacts (Overcash et al., 1983), a better approach for aquacultural sludge management is to use this waste only according to its fertilizer value for crops. The high nitrogen content (4 to 6%) of aquacultural waste makes it valuable to crops as a fertilizer, but limitations for such application have also been identified (Olson, 1991). The first is odor, which prohibits this option in populated areas. The second is the propensity for the applied sludge to form a crust. If the sludge is not thoroughly plowed into the soil, some plant seedlings may be unable to push through the crust. The third limitation is the expense of hauling and spreading. The fourth is the slow nitrogen release rate. Since about 90% of the total nitrogen is in organic form, only one-third of the nutrients can be used in the first year. This makes application in high rainfall areas questionable, since runoff of the unused nitrogen may cause problems in local surface waters.

The guidelines for application rates of aquacultural sludge on cropland have not yet been established. However, it would be reasonable to manage aquacultural waste following guidelines similar to those for managing other types of waste. Most animal waste management plans are based on nitrogen. The fundamental premise is that the rate of animal waste applied on land should not provide more plant available N than crops need, in order to avoid contaminating groundwater with nitrate. Studies on animal manure indicate that crops typically remove between 100 to 200 kg of nitrogen/ha (Overcash et al., 1983). Therefore, a similar rate for application may eliminate nitrogen accumulation in the soil and avoid adverse impacts on the environment. The high nitrogen content that makes aquacultural waste valuable to crops as a fertilizer could, of course, also make over-application of nitrogen more likely. Olson (1991) tested three application rates of trout manure in a greenhouse (111, 222, 336 kg N/ha). Satisfactory results were obtained from application rates of both 222 and 336 kg-N/ha. Subject to further experimental verifications, Olson (1991) recommends 222 kg-N/hectare as a design criterion for aquacultural sludge application on land.

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‘98 Aquaculture Europe Highlights Recirculating Systems *(continued from page one)*

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Hesy Bergambacht B.V.	tank based eel farn	K. Kloet A. de Bondt	Postbus 100 NL-2860 AB Bergambacht The Netherlands	+31182 35 42 02 +31 182 35 41 20 hesy@tref.nl
Fischtechnik Fredelsloh GmbH	tank based eel farn	Uwe Meylahn	D-37186 Moringen Germany	+49 55 55 99 30 +49 55 55 99 30 fischtechnik@t-online.de
Haogenplast Ltd	pond based tilapia farm	R. A. M. Remmerswaal	Kibbutz Haogen 42880 Haogen Israel	+972 9 898 21 03 +972 9 862 06 42 ogenexpo@netvision.net.il
Aqua Optima AS	tank based sea bass farm	Idar Schei	Pir. Senteret N-7005 Trondheim Norway	+47 73 54 54 40 +47 73 54 54 49 office@aquaoptima.com
Idee	tank based sea bass farm	Jacques Trichereau Benoit Husson	740, Av. des Apothicaires F-34090 Montpellier France	+33 49 92 33 160 +33 49 92 33 170 id@hol.fr

All suppliers have established systems operating at commercial farms. For example, Hesy Bergambacht reported to have over 40 recirculating systems growing +/- 1,400 MTON European eel annually in the Netherlands alone. All supplier presentations were standardized to a hypothetical reference farm operation, which was fixed at a 100 MT annual production. It was a unique situation as the suppliers were forthcoming and presented detailed information in the following areas: system components, production schedule, methods and criteria for waste material removal, recirculating flow rates, effluent discharges, power consumption, labor requirements, and/or economic implications. Afterwards, a panel of experts and members of the audience directed specific questions to the supplier representatives. Of note:

- suppliers reported total recirculating flowrates ranged from 11,000 to 13,000 L/min.
- suppliers reported that the farms required 1-3 people to operate.
- suppliers reported biofilters including trickling, fluidized-bed, activated sludge, and submerged media.
- some suppliers reported using a denitrification unit to control nitrate concentrations.
- most suppliers reported using microscreen filters for solids control, although swirl separators and settling basins were also reported.
- most suppliers reported that farms were operated using sequential stocking and harvesting strategies.
- supplier information indicated that the farm’s ratio of annual production to maximum biomass supported ranged from 2.2 to 3.1 yr-1.

For information on obtaining the Aquaculture Europe ‘98 Book of Abstracts contact:
European Aquaculture Society, EAS Secretariat, Slijkensesteenweg 4, B-8400 Oostende, Belgium; +32-59-32 38 59 (ph); 32-59-32 10 05 (fax); or eas@unicall.be (email).

UPCOMING MEETINGS

Aquaculture America '99

The AES will be holding our Annual Meeting at Aquaculture America '99, which is the US Chapter of the World Aquaculture Society's Annual Meeting in the Tampa (Florida) Convention Center, January 27-30, 1999. The AES will be sponsoring a 1-day technical session of contributed engineering papers and two 1/2-day workshops — one on fundamentals and the other an advanced focus on aeration and gas exchange (see Table below).

Day Morning Workshop: Fundamentals *(Intended for the novice)*

8:30 am	*Basic Water Quality and Cycles in Aquatic Systems,* Dr. K. A. Rusch, Louisiana State University
9:15 am	*An Overview of Pond Rearing Techniques & Issues,* Mr. Harry Daniels, North Carolina State University
10:00 am	Break
10:30 am	*Recirculating Rearing Techniques & Issues,* Dr. Steven Summerfelt, Freshwater Institute
11:15 am	*The Hydroponic Approach to Raising Fish,* Dr. Jim Rakocy, University of the Virgin Islands
12:00 pm	*Lunch*

Afternoon Workshop: Advanced Session — Aeration & Gas Exchange

1:30 pm	*Gas Transfer Kinetics, a Refresher,* Dr. Michael Timmons, Cornell University
2:00 pm	*Dynamics and Management of Oxygen and Carbon Dioxide in Photosynthetic Aquaculture Systems,* Dr. David Brune, Clemson University
2:30 pm	*Oxygen Transfer into High Density Tanks and Raceways,* Dr. John Colt, National Marine Fisheries Service
3:00 pm	Break
3:30 pm	*Carbon Dioxide Stripping Options and Advantages,* Dr. Raul Piedrahita, University of California
4:00 pm	*Avoiding Nitrogen Supersaturation In Ponds, Tanks, and Raceways,* Dr. Barnaby Watten, U. S. Geologic Survey

Contributed Aquacultural Engineering Presentations

Aquaculture Wastewater Remediation Using Anion Binding Polymeric Hydrogels
Dimitri R. Kioussis

Organic and Inorganic Carbon Concentrations in Fish Tank Water
Sahdev Singh

The Effects of Light Intensity on Microalgal Production in the Hydraulically Integrated Serial Turbidostat Algal Reactor (HISTAR)
Kelly A. Rusch

A Control System to Simulate Diel pH Fluctuation in Eutropic Aquaculture Ponds
John A. Hargreaves

The Efficiency of Using Liquid Oxygen in Aquaculture – Part I
Enrique Negret-Cordoba

Pushing it to the Limit: An Evaluation of Steady State Performance of a Recirculating System Using Airlift and Bead Filter Technology
Lance E. Beecher

Managing Biofilm Thickness in Fluidized-Sand Biofilters Using Vertical Mixing
Steven T. Summerfelt

Nitrification Comparison of Sand, Bead, and Trickling Media for Biological Filtration in Cold Marine Environments
Brooks Sancier

Evaluation of the SUTA (Siphoning U-Tube Airlift) Pump to Achieve Required Water Flow Rates in Aquaculture Recirculating Systems
Lance E. Beecher

Settling Velocity Characterization of Aquaculture Solids
Kevin B. Wong

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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 and tank systems. During the second day, the AES will sponsor a technical session to include between 12 and 16 contributed scientific paper presentations. The prelimnary workshop programs follow:

Advances in Aquaculture Engineering Around the Globe

8:30	*Aquacultural Engineering in Australia* Dr. John Patterson, James Cook University, Australia
9:10	*Advances in Aquaculture Engineering in Europe* Dr. James Muir, University of Sterling, Scotland
9:50	*Questions and Discussion*
10:00	Break
10:30	*Aquacultural Engineering in Latin America* Mr. Germán Merino, Universidad Católica del Norte, Chile
11:10	*Aquacultural Engineering in Southeast Asia* Dr. Rolando Platon, Southeast Asian Fisheries Development Center, Philippines
11:50	Questions and Discussion
12:00	Lunch break

Advances in Water Reuse Technology in North America

1:30	*Water Reuse Technology in Freshwater Ponds* Dr. David Brune, Clemson University, USA
3:00	Break
3:30	*Water Reuse Technology in Tank Systems* Dr. Thomas Losordo, North Carolina State University, USA
5:00	Session ends

Workshop on Recirculation Technology in Northern Climates

Recirc Today is working closely with Canadian Aquaculture Institute of Charlottetown PEI to present an East Coast recirculation technology workshop. This will held in Moncton, NB, on February 10-11 1999. It will address the general subject of recirculation technology in northern climates.

The program will start with an overview by Dr. Dave Scarratt of the basic biological needs of fish (and shellfish) to keep healthy and thriving in captive conditions. Dave will then outline in very general terms the different elements of recirculation technologies that can be employed for this, while at the same time conserving water and power. This first session will be a basic introduction to the technology to bring the absolute newcomers up to speed. After that, Dr Harold Rosenthal, who has been working on recirculation technology in excess of 20 years will give an overview of the history of recirculation, including some of the more spectacular crashes, and a quick world tour.

After that it's the nuts and bolts: Dan Stechey will lead off with a discussion of the sorts of buildings that are appropriate in these challenging climates, and also look at water supplies. John Holder will discuss tanks, flow calculations, stocking density, and related matters; including the different types of outflow designs and the relative merits of each.

Sean Wilton will deal with the types and functioning of mechanical filters, and Dan Stechey will address temperature control, including the functioning of heating and refrigeration systems, heat exchangers and heat pumps. The final session on the first day will be given by Helène Drouin who will discuss the types and functioning of biofilters. In the evening after dinner there will be a general discussion on emerging technologies led by Dan Stechey.

Steve Summerfelt will start the second morning by guiding us through the intricacies of dissolved gas management, which leads naturally into the use of ozone for disinfection, and other methods of keeping systems clean and aseptic. There will be a session on monitoring and the use of automated or computerized control systems led by Tim Jeppson of Campbell Scientific. Then we'll examine the implications for feeding requirements and disease control. Larry Hammell, Roland Cusack, and Allison McKinnon will take partin this session. Santoash Lall will address the issue of fish nutrition as it relates to recirculation systems. Harald Rosenthal will discuss the huge problem of solid waste management.

The final session will deal with actual case histories. Cliff Goudey of MIT will describe the new salt water system designed for raising fish in water from Boston Harbour and look at marine applications in general. There will be discussion led by Todd Pugsley and Leonard Lahey of UNB on the design of different cold water recirc systems. The economics of their design, construction and operation will be addressed by Michel Couturier.

Throughout the two days there will be lots of opportunity for discussion, and for one-on-one interaction with the different experts. The workshop will be ideal for students at university and aquaculture training program level (and their instructors) who want an intensive two-day introduction to the technology, and also for farmers and entrepreneurs who might see this technology as offering a route to expansion of their operations. It will provide an opportunity for equipment manufacturers to meet some of the scientists and engineers working in the development of the technology. There will not be a trade show, but there will be lots of opportunity for manufacturers dealers and suppliers to meet some of their existing and potential clients, and generate that all-important first hand contact.

For more information, contact:

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AES Newsletter

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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*, a free subscription to the new trade magazine *Recirc Today* (in 1998 only), and ordering information on past and future AES publications.

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   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.

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Elsevier's Journal Aquacultural Engineering

The last 1998 Aquacultural Engineering journals are still shipping as they arrive. Aquacultural Engineering volume 18 (nos. 1-4) and volume 19 (no. 1) have already shipped. The AES will mail the remaining 1998 journals to our journal receiving members as they arrive. Hopefully, it won't be long before the 1999 journals begin shipping. Thank you for being patient.

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. Make cheques payable to the Aquacultural Engineering Society. You do not have to provide education information to become a member.

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