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Megatrends in recirculating aquaculture systems

SYSTEMS ENGINEERING

by Paul Hundley

ROANOKE, VA - In an era marked by declining wild fisheries, burgeoning aquaculture output, and growing fish consumption, recirculating aquaculture systems (RAS) are being challenged to secure their niche in, and to expand their contribution to, increasing global fish production.

To stave off competition from intensive pond-based systems and the mega-capability of net pens, RAS are challenged to establish a cost-effective role in commercial aquaculture.

With more than a decade of solid research, development and commercial application behind them, the issues faced by the RAS industry are numerous, the solutions complicated, and the opportunities great.

But I think the threats are even greater.

At the recent Fifth International Conference on Recirculating Aquaculture in Roanoke, VA, I immersed myself in this subject, spoke to a number of savvy members of the industry, and studied the numerous excellent papers presented at the conference.

As a consequence, I discerned some "megatrends" that I believe are applicable to RAS.

Megatrends

Dan Manternach, of <www.AgWeb.com>, defines "megatrend" as a trend driven by national policy and/or global macroeconomic forces so entrenched and so pervasive that it will take a long time, and a sustained reversal in such policies or forces, to slow, halt, and reverse.

Table 1, at left, summarizes my perception of the current and future applications of RAS life-support and production systems as well as an abbreviated comparative analysis of: the strengths and weaknesses of RAS; the opportunities for and threats to RAS; and established and emerging trends as they relate to several key production factors.

At Roanoke, I discussed the conclusions suggested by this matrix with several members of the industry. Some of their observations are set out below.

Dr. Jim McVey, of the National Sea Grant College Program, was the keynote speaker at the Roanoke meeting. His presentation was entitled, "Facing the competition: Comparing recirculating technology to other production."

The good news? McVey projected that the world aquaculture harvest would equal the global wild capture harvest, at some 60 million metric tons each, in about 20 years.

So, what's the problem?

RAS economics have not worked due to the high capital and operating costs of facilities and production.

It will require larger-scale RAS production systems to be competitive, but downward sliding (commodity) pricing will be the consequence of increased production capabilities and output.

Is this a scenario likely to attract the investment necessary to build larger-scale facilities from venture capitalists who are delighted to see the '90's behind them?

What are the solutions to these problems of economics? No magic bullets are apparent, but we'll explore a few possibilities towards the end of this article.

Genetics

RAS are an important tool in genetics research with regards to development of food fish, ornamentals, and aquatic animals used in sciences related to the improvement of human health.

The aquaculture industry is constantly looking for that next tilapia or hybrid striped bass – the fast growers, the hearty strain, the fish that thrives in a RAS, and grows quickly and efficiently to a profitable market product.

High-end tropical and ornamental fish production is moving indoors to form a large cottage industry that is close to (thanks to overnight delivery services), and closely involved with, local markets.

Small, robust RAS allow the geneticist and the serious hobbyist alike to develop and produce in quantity novel, exceptionally attractive, and valuable tropical and ornamental fish.

Genetic research on human health and disease issues using aquatic animals is a multi-billion-dollar industry around the world. The ubiquitous and hearty zebrafish is the unmistaken champion in the laboratory.

The small, medium and large RAS facilities are supporting countless research programs pursuing cures for and prevention of disease and birth defects.

Fish health

Fish health problems can result from many sources, ranging from environmental degradation, to stock depletion, to intensive culture.

RAS give the fish culturist total control of aquatic environmental factors, allowing the assessment of specific factors affecting fish health. The results of such assessments can lead to the establishment of environmental or other controls and regulations, and help focus efforts for habitat restoration.

RAS provide a robust environment for hatchery and growout production of replenishment, pathogen-free, and high-health fish stocks. Intensive RAS systems allow close monitoring of fish health issues and facilitate development and application of pharmaceuticals and nutriceuticals.

Production systems

When we say production systems we mean the energy, materials, hardware, labor, resources, and logistics required to produce or provide life support for fish.

RAS production systems can be as simple as a collection of table-top or rack-mounted components purchased "off the shelf," or

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they can be highly engineered facilities involving the construction of buildings and the fabrication or installation of components and subsystems supplied by specialty manufacturers.

RAS production systems have evolved significantly over the past decade due, in part, to the biennial RAS Roanoke conference, first held in 1996.

Attendance at the first meeting was overwhelming. Attendance of late has flattened out at about 300 participants.

Some express the view that both RAS technology and application opportunity have also flattened out. Nonetheless, RAS remain a vital, and I say exciting, element of the global aquaculture industry.

Feeds & nutrition

RAS do well with the feeds currently available for various species.

Development of the feeds themselves lags behind RAS technology because the relatively poor economics of the RAS-based production industry make it difficult for feed companies and nutritionists to develop high performance feeds that take advantage of and support RAS intensification.

Newly engineered feeds are needed to maximize the capability of RAS.

Most bulk feeds are designed for use in semi-intense systems where aeration (oxygenation) and high water exchange methods are employed.

Opportunities exist to engineer feeds for intensive and highly intensive low water exchange RAS that employ such solids management devices as double tank drains, microscreen drum filters, radial flow settlers, and foam fractionators, by enhancing characteristics relating to digestibility and formation of feces, while minimizing dissolution of feces and uneaten feed.

These affect water quality and fish health, effluent discharge limits, the taste of the fish experienced by consumers, and profitability for growers.

Possible solutions

Sidestepping direct food fish production issues for a minute, the commercial RAS industry has survived, in part, by establishing itself in other fish production and life support areas.

Researchers employing RAS technology to culture and hold aquatic animals have been quite successful with developments in human health and genetics.

Many large cities have built or expanded major public aquariums for the sake of tourism, urban redevelopment, education,

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Megatrends in Recirculating Aquaculture Systems (RAS)

Production Factors (PFs)	RAS **Strengths**	RAS **Weaknesses**	RAS **Opportunities**	RAS **Threats**	Established or apparent RAS industry standards	Emerging RAS industry standards	Promising initiatives for RAS industry standards	Other significant or promising trends
Genetics	Research systems Bio-secure wrt exotics	Looking for the next tilapia, looking for high value marine fish	Low cost research systems Finding the next tilapia	Poorly designed & operated systems	Modular & rack mounted systems	Better biofilters & tanks Energy efficiency	Increased supplier competition	
Fish Health	Research systems, good designs are robust	Therapeutant impact on biofliters Poor maintenance of bio-security	Low cost research systems	Poorly designed & operated systems	Modular & rack mounted systems	Better biofilters & tanks	Increased supplier competition Reduced fish stress	"Organic" protocols & branding
Production Systems	Good designs are robust, site adapability, great water quality	Poorly designed & operated systems Mismanagement	Improved cost effectiveness w/standardization	Misapplication of systems & components Training and support are lacking	Built up systems	Modular systems are a leading force	Standards of performance-optimization, biological, economic	Large production systems Live seafood conditioning and distribution
Feed & Nutrition	Good feeding effectiveness, solids management Optimum grow-out temperatures	Need RAS specific feeds Benchmarks for comparison	RAS specific feeds Water quality driven feeds High health feeds	Over intensification, feed ingredient cost	Good solids management	Better solids management & other separation methods Cleaner effluents	Feed suppliers are taking interest Looking at income over feed cost vs cost per ton	As the RAS industry expands, feed industry can invest and do more

Paul Hundley graphic

research and quality of life.

After a long honeymoon with personal computers, a lot of people have "found Nemo" and are looking to ornamentals, tropical fish, water gardens, and aquariums for RAS-based entertainment and stress relief.

Jim Michaels, who runs the sturgeon program at the Mote Marine Laboratory's Center for Aquaculture Research & Development in Sarasota, FL, touts the strengths of RAS: bio-secure, site adaptable, and great environmental control.

He believes that large, cost-effective RAS are on the horizon and Mote is currently investing significant resources to demonstrate this is southwest Florida.

Steve Massie, of Freedom Feeds Inc. in Urbana, OH, was a new exhibitor at the recent Roanoke RAS meeting. He is naturally bullish with regards to the strengths of RAS-based production.

"I feel recirc systems are aquaculture's future," he said. "As we improve the engineering, management, and nutritional balance of the systems, profitability will improve and the industry will expand."

Tom Welch, with Zeigler Brothers Inc., said his company has accepted the challenge to engineer and integrate feeds for RAS-based production systems.

"Zeigler's feed focus is on higher digestibility testing, reduced nitrogen discharge, proper amino acid balance, and lowering phosphorus levels for the RAS industry."

John Holder, president of JLH Consulting Inc. and someone with long experience in the business, questioned the inherent sense of bio-security in RAS and challenged engineers and system integrators to improve the design and commissioning of RAS.

"The failure of most RAS can be attributed to lack of proper training and commissioning of the system, in other words lack of after-sales contact," Holder said.

"Also, some systems are over-designed and needlessly complicated. The KISS (keep it simple, stupid) principal should be incorporated more in RAS design."

Harry Westers, of Aquaculture Bioengineering Corp., continued his life-long support of RAS.

"We have come a long way. The easy part is now behind us, the more difficult part is now before us. The law of diminishing returns is here, but we can't give up."

And finally, back to conference keynote speaker Jim McVey. He suggested that possible solutions to the issues and challenges facing RAS include:

- Development of commercial-scale demonstration farms with very clear performance for each species and specific systems;
- Development of generic business plans for individual species and systems;
- Concentrated efforts to improve diets at the species level so as to assure maximum growout efficiency and best flavor of the end product;
- Investment in better genetics for improved growth and disease resistance; and
- Industry focus and cooperation to bring the RAS story to the attention of national leaders and decision makers.

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