From the pages of Fish Farming News
Aquaculture's National Newspaper - Volume 20 - Issue 1 - 2013

Recirculating aquaculture systems:
A consultant's view on planning, design, operation and improvement

Greenhouse RAS system.
Photo courtesy of Michael Rachin

SYSTEMS ENGINEERING

BY PAUL HUNDLEY

Successful recirculating aquaculture system (RAS) based ventures are rooted in financial success, and the various obstacles proffered as excuses for RAS failure are just that, excuses.

The real question is how do we achieve appropriate project scale and adequate investment?

Knowing that RAS can be more efficient and flexible than the declining capture fisheries industry, how do we gather support for a long-term view on RAS venture success?

We can do this.

The two papers listed below from the Aquacultural Engineering journal have been sitting on my desk awaiting review for several months.

After reviewing these articles by Catarina Martins, Maddi Badiola and others, I concluded that these papers offered a great topic for this *Fish Farming News* column.

With input and insights from a few well known aquaculture experts listed below, let's dive in and explore.

With an expert and rational view on sustainability, the Martins paper team concludes that RAS offers the possibility of achieving high production, maintaining optimal environmental conditions, and securing animal welfare while creating a minimal environmental impact.

In spite of the disappointing quantity of survey responses and data to assimilate, the authors of the Badiola paper still provided a great RAS lessons-learned analysis, as well.

So what do we do?

Where do we go from here?

Supply chain analysis

Large scale RAS-based production facilities can and will be successful if the upstream and downstream (supply chain) issues are properly addressed and accounted for in the business plan.

If I grow the wrong fish in the wrong location I will fail.

If my planning, design, and construction budgets are short, I will fail.

If I micromanage, based on a merchant-builder-developer approach, I will fail.

However, if I assemble the right team, express clear concise objectives based on an honest, well-developed supply chain analysis and business plan, I will succeed.

So why so many failures?

Wrong fish, wrong location, wrong budget, wrong design, wrong startup plan, wrong market approach, wrong team!

Not the mere fact that one chose a recirculating aquaculture production system.

Continued on next page

Try and try again

One model for success is: fail, retool, try again; fail, retool, try again; fail, retool, try again …

What transpires between that first failure and success?

Right fish, right location, right design, right budget, right market approach, and right team.

If you want to design and build a $10 million production facility, you should engage objective professionals with the experience and capability to design and build $10 million production facilities (plural).

Scaling up solely on R&D, small project experience and related equipment selections is wrought with peril.

Just because you *can* grow a fish is no reason to do so.

In the paper by Catarina Martins, key sustainability issues which go straight to the financial bottom line include:

- Feed consumption – well designed recirculating aquaculture systems afford lower food conversion ratios and excellent protein production efficiencies;
- Fish production waste – recirculating aquaculture systems incorporate more efficient wastewater treatment processes, as well as resource recovery and conversion; and
- Energy consumption – with good thermal hydraulic design, RAS energy consumption is comparable to capture fisheries.

RAS can provide the means and methods for nutrient conversion to feed and to alternative products and fuel which will contribute significantly to venture cash flow.

The paper by Maddi Badiola focuses on the shortcomings of the planning, design, construction, and operation of RAS solids removal and biofiltration subsystems, with poor design often following on the heels of poor design.

Excessive small, medium, and large suspended solids are indicative of excessive RAS loading with feed and fish.

Too much of our industry comes up short in these key process areas.

Badly designed equipment was touted as the most common cause of problems for on-growing systems.

Key design and operating issues include:

- Wrong design approach, including inaccurate and optimistic design calculations;
- Inappropriate management, including lack of training:
- Maintenance issues resulting in poor water quality;
- Poor equipment selections; and
- Lack of response by consultants and suppliers to unforeseen circumstances.

The problem is the answer …

A comprehensive "commissioning" approach with its focus on quality is the best tool for assuring success.

Unfortunately, the money managers will likely view this solution as too costly because they do not understand the problem.

What do the experts say?

Durwood Dugger, president of Biocepts International Inc. – My sense is that we are too focused on engineering and technology and do not focus enough on prioritizing economic sensitivities of the RAS process to accomplish successful economic outcomes.

Basic biological and engineering technologies exist and are ready to adapt and install in optimized RAS design. This optimization with regard to economic efficiency is what's missing.

On a mass balance and life cycle basis, no other form of aquaculture offers as much designer and manager control over inputs as does RAS technology.

Tony Schuur on the job in the aquaculture lab at Southern Illinois University-Carbondale.

Photo courtesy of Prairie Farmer magazine

At Biocepts we have turned the perceived "open" aquaculture system advantage of little or no waste feed nutrient processing costs on its head.

We view the primary advantage of RAS is having the ability to capture wastes – which is not necessarily a cost burden.

It should be noted that in all "fed" aquaculture, only about 15% of feed input by dry weight ends up as product. And feed is more than likely to be the largest single overhead cost.

Further, these 85% wastes which typically go "down the drain" are an economic resource, a "sunk cost" for RAS designers to draw upon, and – through waste recovery – a major opportunity for reducing operating overhead.

Michael Rachin, RAS design specialist at AquaGreen –Recirculating aquaculture systems fail mainly due to human error and biosecurity issues.

But the right team and strict operational discipline with regards to biosecurity will bring success.

Also, RAS facility operations need to reflect and link strongly to the supply chain.

Recirculating aquaculture systems depend on three major overhead costs which are addressed with emphasis by AquaGreen designs: feed, energy, and manpower.

- Feed – only with clear water, no deeper than 3 to 4 feet where tank bottom is clearly visible can you control feed without waste. Because of the limited size of a tank, the amount of fish is known, along with the feeding formula related to weight of fish – thereby everything is under control.
- Energy – low-head pumps with at least a 60 cubic meter fish tank volume for 1 kW. Maximum power consumptions should be 4 kWh per kg of fish.
- Manpower – to operate a 600 metric ton AquaGreen production facility, you need 7 people – 2 biologists and 1 technician. The rest are trained laborers. Harvesting of one

pool – 15 metric tons of fish – can be easily managed by two people.

Tony Schuur, principal consultant at Aquaculture Management Services – An aquaculture venture in any particular instance is not in competition with anyone.

It competes against its own goals in the context of accomplishing a profit margin.

With time, capture fisheries will simply dwindle as a percentage of the seafood available and become increasingly irrelevant to aquaculture and seafood in general.

I have spent most of my life creating structured approaches to aquaculture development that follow some rational order.

The challenge is to integrate "facts" in the context of science, order, rational choices, and decisions.

Failure has nothing whatsoever to do with RAS.

Sometimes selecting an RAS approach is good. Sometimes it is very bad.

Engineering of unit processes and selection of equipment often neglects any reasonable margins of safety.

There are people who know how to design RAS with a high degree of reliability.

Unfortunately, the managers are sometimes loath to allocate resources for objective design when they can get their engineering done for free by an equipment provider with not a clue of the whole context.

The result is a planning and design deficit that is not visible until production operations brings it to light.

It is difficult to get investors to invest in professional planning and design because the managers have not generally experienced the high failure rate that is typical of poor planning and project implementation.

The British engineers that I have known use the word "commission" as a vital intrinsic component of the planning, design, and construction process.

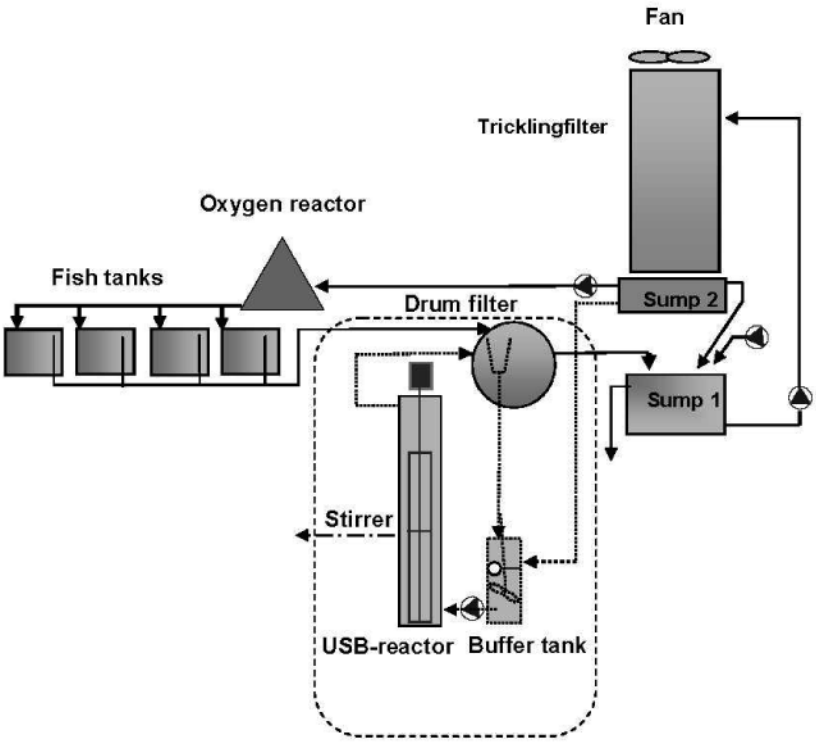
It also means that before you operate commercially, the facility should be tested thoroughly to determine that it complies with design specifications and performance objectives.

Conclusions

The challenge for RAS consultants and designers is whether they can use captured waste nutrients to offset other RAS production costs, or whether they will just write it off as waste removal expenses.

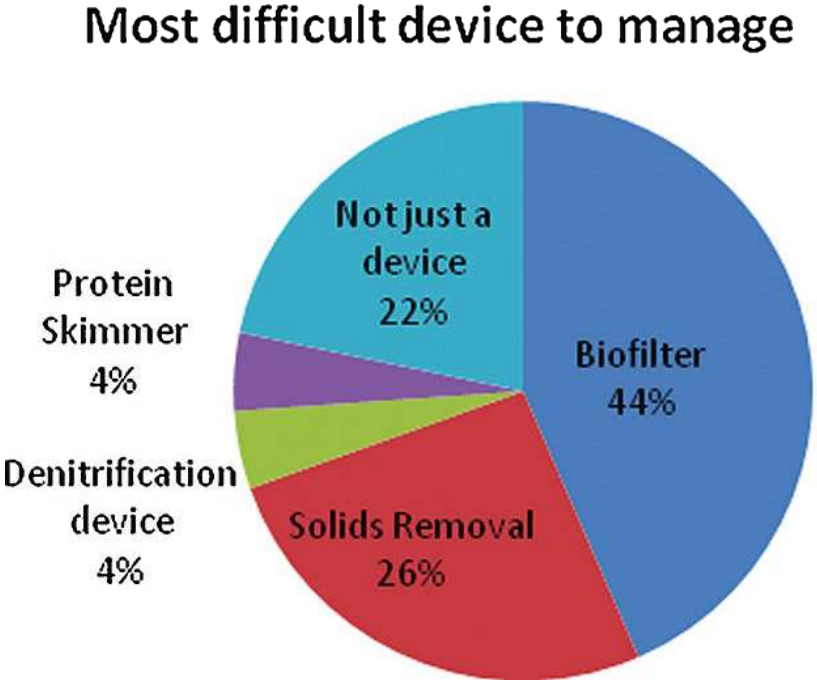
There is the perception that RAS in the US has been primarily the focus of small business ventures.

Continued on next page



Innovative RAS using a denitrification (USB) reactor.

Graphic courtesy of Elsevier, Martins et al



Graphic courtesy of Elsevier, Badiola et al

The best future lies with total vertical integration of large-scale operations to reach economic feasibility.

Advocates for RAS production systems should educate clients and investors in the need for engineered solutions that "commission" RAS facilities – based on integrated supply chain analyses and design solutions that bring forth the experience of the industry.

Go team!

Paul Hundley is manager of aquaculture systems and facilities at HTH Engineering & Equipment LLC. HTH specializes in recirculating aquaculture systems and provides professional aquaculture and aquacultural engineering services. Hundley has more than 35 years of experience in planning, design, construction, operation, maintenance, and improvement of commercial, industrial and institutional facilities and has been working in aquaculture since 1988. He can be reached via phone (704) 577-3574; email <paul.hundley.jr@gmail.com>; or on the web at <www.HTHaqua.com>. Copies of this and other Systems Engineering articles are available on request.

Acknowledgements

I wish to thank my contributing experts: Durwood Dugger, Biocepts International Inc., <ddugger@biocepts.com>; Michael Rachin, AquaGreen, <aquagreenfarm@gmail.com>; Tony Schuur, Aquaculture Management Services, <amschuur@aol.com>.

For additional reading:

● "New Developments in Recirculating Aquaculture Systems in Europe: A Perspective on Environmental Sustainability" by Catarina I.M. Martins and others, published in *Aquaculture Engineering*, Nov. 2010, Volume 43, Pages 83 – 93.

● "Recirculating Aquaculture Systems (RAS) Analysis: Main Issues on Management and Future Challenges" by Maddi Badioa and others, published in *Aquaculture Engineering*, Nov. 2012, Volume 51, Pages 26 – 35.

RAS shrimp nursery.
Photo courtesy of Durwood Dugger

Journal homepage: http://www.journals.elsevier.com/aquacultural-engineering/