Aquaculture Technology;
Ponds to Super-Intensive Production

Aquaculture Intensification from 1960 to 2020

SYSTEM	Yield kg/ha	Feed kg/ha-d	Aeration KW/ha	Type (g-C/m^2 d)	VSS mg/l	Timeline
Extensive	1,124-2,247	11-34	Wind	Algal (0.5-1)	10-20	1960
Semi- Intensive	4,494-6,742	56-112	1.8-3.7	Algal (2-3)	50-100	1980
Intensive pond	11,235-13,483	112-168	11-22	Mixed (3-4)	100+	1990
PAS/SP	16,854-21,348	225-280	13--18	Algal (6-12)	50-100	2000
Super nitrifying	44,943+	1,123	92-111	Nitrification	300-400	2006
Super heterotrophic	44,943+	1,123/674	111-148	Heterotrophic	300-400	2006
Rapid Removal	34,000-50,000	1,685	123-140	Intensive Nitrification	70-80	2020

Over six decades, improved technology increased productivity, from ponds at 2,000- 5,000 lbs/acre to, enhanced-photosynthetic, intensive ponds, using aeration and water mixing expanding to 10,000 to 18,000 lbs/acre, to bacterial treatment in super-intensive recirculating aquaculture systems yielding 30,000 to 50,000 lbs/acre

Pond Fish and Shrimp Culture in Warm Climates

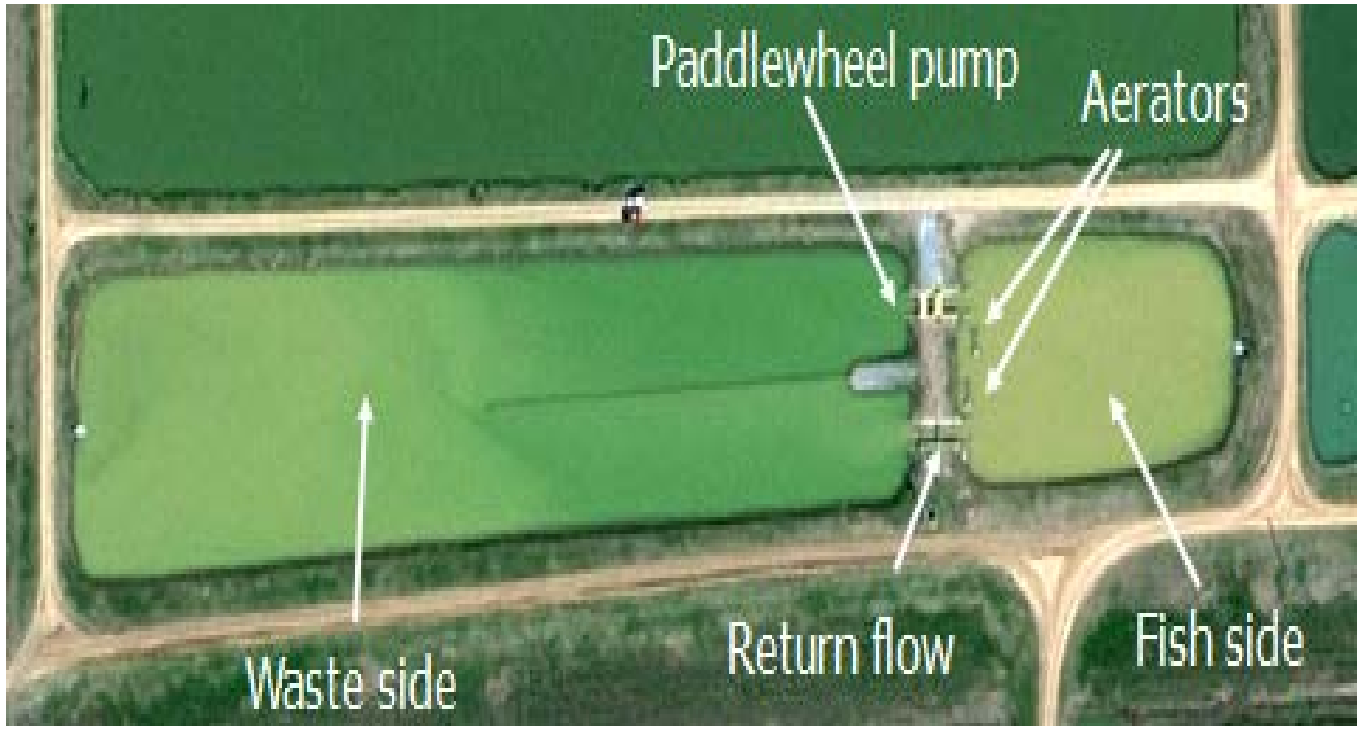
Intensive aeration allowing catfish to expand from 2,000 to 10,000 lbs/acre

Intensive aeration and water discharge allowing shrimp to expand from 1,000 to 10,000 lbs/acre

Partitioned Aquaculture at Clemson University

Enhanced algal production using water-mixing in Partitioned Aquaculture Systems expanding catfish production to 15,000 to 18,000 lbs/acre

Split-ponds at Warmwater Aquaculture Center, Stoneville Mississippi



A lower-cost version of the PAS, the Split-pond, at Mississippi WWAC demonstrates catfish production at 12,000 to 16,000 lbs/acre

In-Pond Raceways utilizing existing farm ponds

In-pond raceway, at Auburn University for catfish production

In-pond raceways in Missouri farm pond

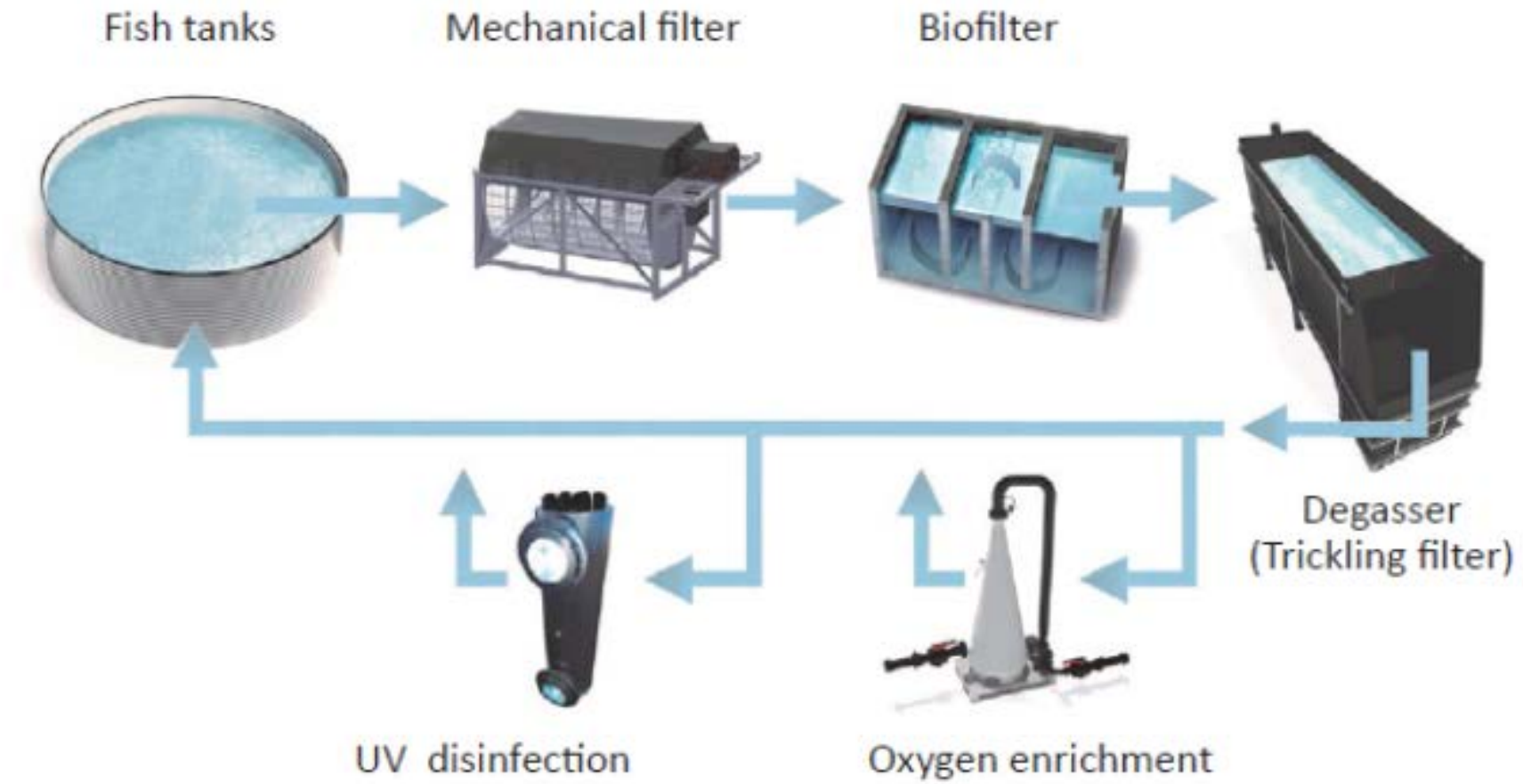
Intensive RAS with limited or zero-discharge to environment*

Outdoor Ambient-Temperature RAS

Year-round, Indoor, Controlled-Temperature RAS

*A Guide to Recirculation Aquaculture; Jacob Bregnballe. FAO Publication, 2015

Recirculating Aquaculture Systems (RAS) Water Treatment Components



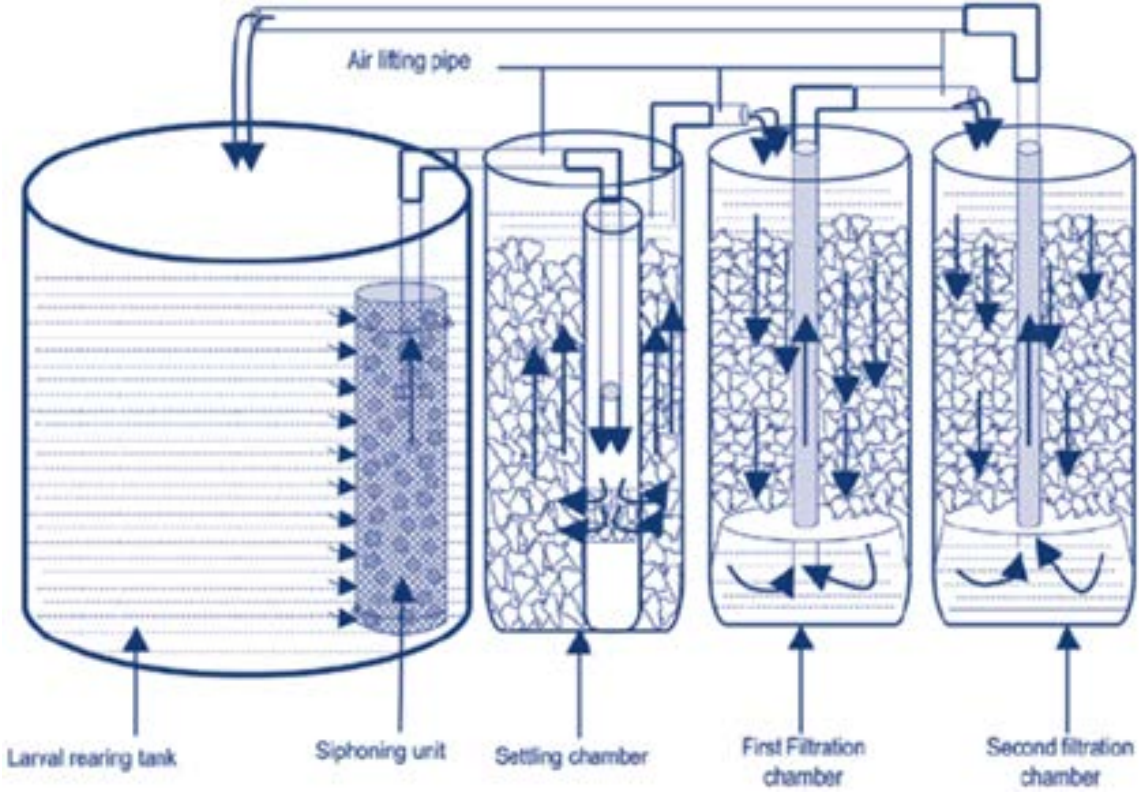
In cooler zones, or were water discharge is restricted, RAS units provide complete, continuous water treatment, consisting of mechanical filtration, biological treatment and aeration/stripping, oxygen enrichment and UV disinfection

Large-scale open air RAS in warm climate

Hybrid Stripped Bass Production at Kent SeaTech Corporation in California

Clean-water RAS uses fixed film biofilter to treat ammonia

Plastic aquaculture biofilter media for bacterial support



Aquaculture biofilter prepared from indigenous materials in Bangladesh; Reported by M. Shahadat Hossain, et al.

Commercially available biofilters and constructed foam-fractionation

Biofilter from “Aquaculture Systems Technology™”

Bead filter used at Auburn University

Foam Fractionation for Marine Shrimp at Texas A&M

Super-Intensive, biofloc aquaculture uses high levels of microbial solids (300 mg/l) suspended within culture water to treat ammonia

University of Missouri Zero-Discharge Shrimp Production

Aquaculture Production in Midwest and Missouri

- Cooler climate in Missouri suggests indoor, climate-controlled shrimp and fish culture for maximum production and profit
- Biofloc-RAS best suited for warm-water, high-solids tolerant species; tilapia, marine-shrimp, bass, catfish, carp
- Biofilter-RAS best suited for cool or cold-water, clean-water species: trout, salmon, yellow-perch, bass

Advantages of RAS;

100-fold Reduction in Water Usage and Reduced Environmental Impact*

Type of system	Consumption of new water per kg fish produced per year	Consumption of new water per cubic meter per hour	Consumption of new water per day of total system water volume	Degree of recirculation at system vol. recycled one time per hour
Flow-through	30 m^3	1 712 m^3/h	1 028 %	0 %
RAS low level	3 m^3	171 m^3/h	103 %	95.9 %
RAS intensive	1 m^3	57 m^3/h	34 %	98.6 %
RAS super intensive	0.3 m^3	17 m^3/h	6 %	99.6 %

*A Guide to Recirculation Aquaculture; Jacob Bregnballe. FAO Publication, 2015

Disadvantage of RAS; Increased Cost of Production

TYPE/YIELD	Break-Even (whole)	Farm-gate (whole)	Wholesale (processed)	Retail (processed)
POND				
Catfish (0.32 lb fillet)	0.80-1.00/lb	0.85-1.25/lb	5.00-6.00/lb	8.00-11.00/lb
Shrimp (0.6 lb tails)	1.50-1.90/lb	2.00-3.00/lb	5.00-6.00/lb	5.00-12.00/lb
RAS				
Shrimp (0.6 lb tails)	4.00-8.25/lb			13.00-18.00/lb whole
Bass (0.32 lb fillet)	4.00-6.00/lb	5.00-6.00/lb	15.00-18.00/lb	20.00-28.00/lb

Pond Production costs of $1-2/lb vs RAS costs of $4-8/lb;

RAS production requires direct sales to restaurants or consumers to insure profitability

Presentations/Resources

MU Extension Aquaculture Website

https://extension.missouri.edu/programs/aquaculture-extension

Short Video Presentations

1) Importance of Aquaculture; Impact on US Seafood Supply and Economy

2) Aquaculture in the Midwest; Economic Opportunity for Missouri Farmers?

3) Aquaculture Technology; Ponds to Super-Intensive Production