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Tilapia co-culture for management of algal production in a “High-Rate Pond” modified for fish production, increasing carry capacity to 19,000 lb/acre
OBJECTIVES; 2014 & 2015
Comparisons of Split-Ponds (SP) and Intensive Ponds (IP) at MS-State Delta Branch Experiment Station vs. Conventional Ponds (CP) and Partitioned Aquaculture Systems (PAS) for production of hybrid catfish (*Ictalurus punctatus* x *I. furcatus*)
MS Split-Pond; 2014

1995-2008 Clemson PAS (0.05-2.0 ac)  
2014 MS Intensive Pond (2.0 ac)
MS Split Ponds and Intensive Ponds; 2015

IP-6W
3.9 ac
6.0 ft-deep
Three 10-hp aerators

IP-5W
3.8 ac

SP-H4

IP-5E
3.9 ac

SP-H3
5.5 ac
4.3 ft-deep

SP-H1

Four 10-hp aerators

1.5 ac
6 ft-deep
Mississippi Exp Station Split-Pond

- Paddle
- Oil hydraulic drive
- Return channel
High-HP ponds; D-5 and D-6

- 1.93 acres water, 5.5 ft deep
- 6 hp/acre aeration capacity
MS Split-Ponds; H-7 and #26

- 1 acre, 5-6 ft deep earthen fish culture pond (1.8 million gallons)
- 3.5 acre 4-5 ft deep water treatment pond (averaging 6.7 million gallons)
- Cross-levee canals, paddlewheel delivering 10,000-12,000 gpm flow yielding 4-6 fish zone water exchanges/12 hrs.
- 6 hp/acre aeration capacity
## Carrying Capacity and Feeding

<table>
<thead>
<tr>
<th>Type</th>
<th>Max catfish carrying capacity (lbs/acre)</th>
<th>Feed loading ave/max (lbs/acre-day)</th>
<th>FCR lbs-feed/lbs-fish</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1995-2008</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAS</td>
<td>15,000-18,000</td>
<td>160/250</td>
<td>1.4-1.6</td>
</tr>
<tr>
<td>CP</td>
<td>5,000-7,500</td>
<td>100/150</td>
<td>~2.0</td>
</tr>
<tr>
<td><strong>2014</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>14,032</td>
<td>120/280</td>
<td>1.66</td>
</tr>
<tr>
<td>IP</td>
<td>18,245</td>
<td>107/270</td>
<td>1.75</td>
</tr>
<tr>
<td><strong>2015</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>12,800-14,100</td>
<td>110/216</td>
<td>1.9-2.0</td>
</tr>
<tr>
<td>IP</td>
<td>9,200-13,800</td>
<td>84/161</td>
<td>1.8-1.9</td>
</tr>
</tbody>
</table>
Measurements

2014
Daily; pH, temp, TAN, O2 profiles, light/dark bottles, with/without nitrification inhibitor, sedimentation rates, Seechi-disk

2014/2015
Daily; feed application, energy consumption, in-situ O2 and temp controlling aerators and paddles

Every 14 days; pH, temp, TAN, NO₃, NO₂, alkalinity, chl-a, total-N. algal and zooplankton identification and enumeration

Seasonal; fish yield and survival
# Oxygen and Nitrogen Mass Balances

**Oxygen (lbs/acre-day)**

<table>
<thead>
<tr>
<th>System</th>
<th>Surface</th>
<th>Fish</th>
<th>Photosynthesis</th>
<th>Deep</th>
<th>Photo % of Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clemson PAS</td>
<td>+72</td>
<td>-150</td>
<td>+180</td>
<td>-102</td>
<td>120 %</td>
</tr>
<tr>
<td>Conventional Pond</td>
<td>+40</td>
<td>-50</td>
<td>+32</td>
<td>-22</td>
<td>64 %</td>
</tr>
<tr>
<td>MS Split Pond</td>
<td>+40</td>
<td>-180</td>
<td>+140</td>
<td>-76</td>
<td>78 %</td>
</tr>
<tr>
<td>MS High-HP Pond</td>
<td>+80</td>
<td>-237</td>
<td>+157</td>
<td>-78</td>
<td>66 %</td>
</tr>
</tbody>
</table>

**Nitrogen (lbs/acre-day)**

<table>
<thead>
<tr>
<th>System</th>
<th>Feed</th>
<th>Fish</th>
<th>Photosynthesis</th>
<th>Recycle</th>
<th>Recycle % of Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clemson PAS</td>
<td>+8.2</td>
<td>+6.2</td>
<td>-11.9</td>
<td>+5.8</td>
<td>93%</td>
</tr>
<tr>
<td>Conventional Pond</td>
<td>+2.2</td>
<td>+1.7</td>
<td>-2.2</td>
<td>+0.5</td>
<td>30%</td>
</tr>
<tr>
<td>MS Split-Pond</td>
<td>-5.8</td>
<td>+4.4</td>
<td>-8.7</td>
<td>+4.3</td>
<td>98%</td>
</tr>
<tr>
<td>MS High-HP Pond</td>
<td>+8.0</td>
<td>+6.0</td>
<td>-10.5</td>
<td>+4.5</td>
<td>75%</td>
</tr>
</tbody>
</table>
## Split-Pond Treatment Zones (day-time)

<table>
<thead>
<tr>
<th>Water Treatment 4.3 ft, (72% of total volume)</th>
<th>Fish Culture 6.0 ft, (28% of total volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Photosynthesis; Top 30%</em></td>
<td>12,000 gpm</td>
</tr>
<tr>
<td><em>Aerobic Treatment; Top 65%</em></td>
<td>5 fish-zone exchanges/day</td>
</tr>
<tr>
<td><em>Anoxic Treatment; Variable 15%</em></td>
<td>Aeration = off</td>
</tr>
<tr>
<td><em>Anaerobic Treatment; bottom 35%</em></td>
<td></td>
</tr>
</tbody>
</table>
Split-Pond Treatment Zones (night-time)

<table>
<thead>
<tr>
<th>Water Treatment 4.3 ft, 72% of total volume</th>
<th>Fish Culture 6.0 ft, 28% of total volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic ~ 100%</td>
<td>Exchange = off</td>
</tr>
<tr>
<td></td>
<td>Aeration capacity</td>
</tr>
<tr>
<td></td>
<td>=30 hp/acre</td>
</tr>
</tbody>
</table>
## Algal Removal Mechanism, Density and Dominant Algal Species

<table>
<thead>
<tr>
<th>Type</th>
<th>Algal Density (cm / mg/l)</th>
<th>Algal removal mechanism</th>
<th>Algal genera</th>
<th>Algal cell age (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAS</td>
<td>18 / 80</td>
<td>tilapia/sedimentation</td>
<td>green</td>
<td>3.3</td>
</tr>
<tr>
<td>SP</td>
<td>13 /110</td>
<td>zooplankton/sedimentation</td>
<td>bluegreen(^1)</td>
<td>4.6</td>
</tr>
<tr>
<td>IP</td>
<td>12 / 115</td>
<td>zooplankton/sedimentation</td>
<td>bluegreen(^1)</td>
<td>3.8</td>
</tr>
<tr>
<td>CP</td>
<td>13 / 110</td>
<td>zooplankton/sedimentation</td>
<td>bluegreen(^2)</td>
<td>9.0</td>
</tr>
</tbody>
</table>

\(^1\) Oscillatoria  
\(^2\) Oscillatoria, Microcysts Anabaena
Dominate Photosynthetic Organisms
Split Pond vs. Intensive pond; 2015

Bluegreen dominance more sustained in Intensive-Pond vs. Split-Pond
PAS Bluegreen Biomass; 1999
(percent of total)

% Bluegreen
UNIT 3

Tilapia filter-feeding (@25% of catfish biomass)
reduces bluegreen dominance late season
Zooplankton and Algal Settling (2014)

- High algal settling rates in SP and IP
- Bluegreen algae enmeshed in detritus
- Large zooplankton populations

Rapidly settling algae

High zooplankton numbers
Summary

Partitioned Aquaculture System
- Continuous paddlewheel mixing, 100% aerobic, 3.0 hp/acre aeration
- 18,000 lb/acre in 5% of system (raceway culture),
- Rapidly growing green algae controlled by tilapia, few zooplankton
- 80 mg/l algal density, 25% algal respiration,
- No nitrification.

Split-Pond
- Daytime mixing with paddle wheels, 80% anaerobic at night, 5.7 hp/acre aeration
- 12,800 - 14,100 lb/acre in 28% of system
- Rapidly growing bluegreen algae, rapid sedimentation, high zooplankton numbers
- 115 mg/l algae density, 50% algal respiration
- Nitrification = 20% of treatment
- More consistent algal bloom, lower bluegreen dominance vs. Intensive-Pond
- Lower capital cost compared to PAS
Summary continued

**Intensive Pond**
- Night-time mixing and aeration at 7.9 hp/acre, anaerobic % unknown
- 9,200-18,200 lb/acre in 100% of system volume
- Rapidly growing bluegreen algae, rapid sedimentation, high zooplankton numbers
- 110 mg/l algae density, 50% algal respiration,
- No nitrification
- Bird predation harder to control
- Lower capital cost compared to SP

**Conventional Pond**
- Night-time mixing and aeration at 2.6 hp/acre, anaerobic % unknown
- 7,500 lb/acre in 100% of system volume
- Slowly growing bluegreen algae, sedimentation & zooplankton variable
- 110 mg/l algae density, 50% algal respiration,
- Nitrification unknown
- Lower capital cost compared to IP
Questions

- Raceway culture with higher degree of control over algal population justify higher PAS cost?
- Reduced cost of SP and IP given lower degree of control with bluegreen dominance justified? Is system behavior reproducible?
- Reduced cost, lower production, and lower level of control of CP justified? Will variable algal dominance lead to off-flavor issues?
- PAS control vs. CP low-cost: Systems-wide cost/lb vs. risk comparison?
Recent video posted by David Cline at Auburn University on In–Pond Raceways, PAS, and Split–Ponds

- [https://www.youtube.com/watch?v=AXIrf1dzpAY](https://www.youtube.com/watch?v=AXIrf1dzpAY)