COMMERCIAL SHRIMP (*Litopenaeus vannamei*) FARMING USING BIOFLOC SYSTEM

Nyan Taw

Kuala Lumpur, Malaysia
19 June 2010
Introduction

Shrimp farming has become competitive and as such the technology utilized needs to be efficient in all aspects – productivity, quality, sustainability, bio-security and to be in line with market demand.

Basic Concept of Biofloc Technology

Yoram Avnimelech, 2000, 2005

Data on feed protein utilization

- ASP Tilapia ponds (Avnimelech) 45%
- ASP ShConventional fish, shrimp ponds 20-25%
- Shrimp ponds (McIntosh) 45%
- Closed shrimp tanks (Velasco) 63%
- ASP shrimp ponds, $^{15}$N study
  Michele Burford et al. 18-29% of total N consumption
The ‘Biofloc (Floc)’

FLOC COMMUNITIES AND SIZE

The biofloc
Defined as macroaggregates – diatoms, macroalgae, fecal pellets, exoskeleton, remains of dead organisms, bacteria, protest and invertebrates. (Decamp, O., et al 2002)

As Natural Feed (filter feeders – L. vannamie & Tilapia): It is possible that microbial protein has a higher availability than feed protein (Yoram, 2005)
Basic of BFT in Shrimp Farming

1. High stocking density - over 130 – 150 PL10/m²
2. High aeration – 28 to 32 HP/ha PWAs
3. Paddle wheel position in ponds
4. HDPE / Concrete lined ponds
5. Grain (pellet)
6. Molasses
7. Expected production 20–25 MT/ha/crop

Feed & grain application and biofloc

High density

Grain pellet

Bioflocs

Dark Vannamei

Red Vannamei
# Pond Water Preparation

For already treated water in series of treatment reservoirs in HDPE lined 0.5 ha production ponds

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
</tr>
</thead>
</table>
| 1   | Urea 8 kg & TSP 1 kg  
     | Grain pellet 30 kg & Dolomite 50 kg |
| 2   | Tea seed cake 15 ppm  |
| 4   | Grain pellet 30 kg & Dolomite 50 kg |
| 6   | Grain pellet 30 kg & Dolomite 50 kg |
| 8   | Grain pellet 50 kg, Molasses 8 kg & Kaolin 50 kg |
| 10  | Grain pellet 50 kg |
| 12  | Kaolin 50 kg |
Pond Operation
High Aeration

Vannamei - Bacterial Floc PWA 15 HP (7 x 1HP and 4 x 2HP)

NOTE:
PWA 1 HP
PWA 2 HP
Rope

A
F
G
C
E
I
H
D
B

4 2 3

Paddle Wheels position

Feeding

Siphoning
Sampling Method
Measuring procedure

1 liter / 2 places/ 15 cm deep/ between 10-12 am

Let it settled for 15-20 minutes

Read density of flocs in cone (ml/l)
STAGES

FLOC Development stages (vol) in pond

Stage 1: Floc found but cannot be measured (subjective)

Stage 2: Floc found in small quantity, < 1.0 ml/litre

Stage 3: Floc found abundance, 1.0 – 5.0 ml/litre

Stage 4: Floc found abundance, 5.1 – 10.0 ml/litre

Stage 5: Floc found abundance, > 10.1 ml/litre
Feed and Growth

Avg. F/D, GP Consumption & Growth Performance

GP (kg), F/D (kg)

DOC (days)

MBW (g)

F/D GP MBW
‘Floc’ Development

Company Commercial ponds - Block 71 Module 24 Row 47
Control Biofloc

Brown biofloc

Green biofloc

Black biofloc

Black gill

Biofloc- general view at surface
Pond environment and Control - feed/grain/floc & Performance - growth

WATER PARAMETER (X 10)

- DO, pH, TRANSPARENCY
- NO2-N, SALINITY (X10)
- PO4-P, TAN, CO2
- MBW (g), Floc (ml/1L)

SHRIMP PERFORMANCE

- Vannamei STD 131 pcs./m2
- Production: 8,971.8 kg; MBW: 16.36 g SR: 83.9%
- FCR: 1.0 ADG: 0.14 DOC: 113

Chlorophyl a (µg/l)

Vannamei STD 131 pcs./m2
Production: 8,971.8 kg; MBW: 16.36 g SR: 83.9 %
FCR: 1.0 ADG: 0.14 DOC: 113

Feed/day (kg) & Grain Pellet (kg)
Pond Address: 82.01.04
Pond Type: Full HDPE
Stocking Date: 19-Jun-2004
Harvest Date: 23-Oct-2004
Density: 295 pcs/m²
Harvest DOC: 127 days
MBW: 16.1 g
ADG: 0.13 g/day
SR: 87.35%
FCR: 1.47
Biomass/0.5 ha: 20,753.3 kg
Belize, Central America
Biofloc system culture

Belize Aqua Ltd – A view

BELIZE SHRIMP FARM (McIntosh, 2000b&c)
L. vannamei Mexican strain
Pond size 1.6 hectare
Pond type Fully HDPE lined
Aeration input 48 HP of PWA
System Heterotrophic zero water exchange
Production 13,500 kg/ha/crop
Carrying capacity 550 kg shrimp/HP of PWAs
Farms Using Bio-floc Technology in Indonesia
Shrimp Farms in Indonesia where BFT was applied

Global Medan

CPB Lampung

Bali
First Biofloc Commercial Trial
Central Pertiwi Bahari (CP, Indonesia)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fry Code</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tot pond</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>STD (pcs/m²)</td>
<td>131</td>
<td>131</td>
<td>130</td>
<td>131</td>
<td>131</td>
<td>131</td>
</tr>
<tr>
<td>DOC (day)</td>
<td>148</td>
<td>146</td>
<td>150</td>
<td>146</td>
<td>146</td>
<td>147</td>
</tr>
<tr>
<td>Biomass (kg)</td>
<td>11,337</td>
<td>10,587</td>
<td>10,650</td>
<td>10,886</td>
<td>11,256</td>
<td>10,883</td>
</tr>
<tr>
<td>MBW (g)</td>
<td>16.78</td>
<td>17.66</td>
<td>17.61</td>
<td>17.89</td>
<td>16.38</td>
<td>17.4</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.2</td>
<td>21.2</td>
<td>26.8</td>
<td>21.4</td>
<td>21.3</td>
<td>23.0</td>
</tr>
<tr>
<td>FCR (- GP)</td>
<td>1.01</td>
<td>1.09</td>
<td>1.08</td>
<td>1.03</td>
<td>0.98</td>
<td>1.04</td>
</tr>
<tr>
<td>FCR (+ GP)</td>
<td>1.69</td>
<td>1.83</td>
<td>1.82</td>
<td>1.70</td>
<td>1.64</td>
<td>1.73</td>
</tr>
<tr>
<td>SR (%)</td>
<td>100.0</td>
<td>91.6</td>
<td>92.8</td>
<td>92.8</td>
<td>105.0</td>
<td>95.9</td>
</tr>
<tr>
<td>ADG (g/day)</td>
<td>0.11</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Prod (g/m²/crop)</td>
<td>2,267</td>
<td>2,118</td>
<td>2,130</td>
<td>2,177</td>
<td>2,251</td>
<td>2,176</td>
</tr>
</tbody>
</table>

Semi-lined 0.5 ha ponds

Nyan Taw (2005, 2006)
Production Performance
TD - R&D, Trail & Commercial

Floc System Production R&D, Trial and Company Commercial Ponds
Period 2003 - 2005

Number of pond

Production range (kg/5000m²)

- R&D: Density 100-200 pcs/m², MBW 16.41 g, Biomass 9.905 kg, SR 81.7 %, FCR 1.29 (number of ponds = 46)
- TRIAL: Density 140 pcs/m², MBW 16.56 g, Biomass 10.082 kg, SR 87.0 %, FCR 1.42 (number of ponds = 13)
- CCP: Density 130 pcs/m² (standard), MBW 16.99 g, Biomass 9.557 kg, SR 85.5 %, FCR 1.21 (number of ponds = 131)
Energy efficiency
Air diffusers (PDP) - 3 hp air diffusers + 9 hp PWA’s = 12 HP in Floc system

<table>
<thead>
<tr>
<th>Item</th>
<th>12 HP Energy (3 HP Air Diffusers + 9 HP PWA's)</th>
<th>15 HP Energy (PWA's 15 HP) Control</th>
<th>12 HP Energy (PWA's 12 HP) confirm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of ponds</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Stocking density (pcs/m²)</td>
<td>131</td>
<td>131</td>
<td>101</td>
</tr>
<tr>
<td>Period (day)</td>
<td>137</td>
<td>137</td>
<td>139</td>
</tr>
<tr>
<td>Harvest Biomass (kg)</td>
<td>9,984</td>
<td>10,056</td>
<td>7,575</td>
</tr>
<tr>
<td>Productivity (kg/Ha)</td>
<td>19,968</td>
<td>20,111</td>
<td>15,150</td>
</tr>
<tr>
<td>Harvest MBW (g)</td>
<td>15.4</td>
<td>16.0</td>
<td>16.0</td>
</tr>
<tr>
<td>FCR</td>
<td>1.41</td>
<td>1.42</td>
<td>1.59</td>
</tr>
<tr>
<td>Survival Rate (%)</td>
<td>99.1</td>
<td>96.2</td>
<td>93.7</td>
</tr>
<tr>
<td>Acc. ADG (g/day)</td>
<td>0.11</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Carrying Capacity (kg/HP)</td>
<td>832.0</td>
<td>670.4</td>
<td>631.3</td>
</tr>
</tbody>
</table>

Pond performance
# Global Medan

## Partial Harvest/Biofloc Performance

Partial Harvest Performance with Bio Floc Technology (February - July 2008)

<table>
<thead>
<tr>
<th>Pond/size</th>
<th>System</th>
<th>Energy Input</th>
<th>Density</th>
<th>Partial</th>
<th>Harvest</th>
<th>Production</th>
<th>FCR</th>
<th>SR</th>
<th>Energy Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 5896 m²</td>
<td>Phyto</td>
<td>16 (PW) 27 (PW)</td>
<td>100</td>
<td>1</td>
<td>118 434 47</td>
<td>11,461 19,439 0</td>
<td>1.60</td>
<td>75.72</td>
<td>560* 720</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>127 11,027 43</td>
<td>23.26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 5896 m²</td>
<td>Bio Floc</td>
<td>18 (PW) 31 (PW)</td>
<td>145</td>
<td>1</td>
<td>108 2,092 59</td>
<td>13,508 22,910 0.59</td>
<td>1.20</td>
<td>84.07</td>
<td>680* 739</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>131 10,400 52</td>
<td>19.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 5940 m²</td>
<td>Bio Floc</td>
<td>18 (PW) 30 (PW)</td>
<td>146</td>
<td>1</td>
<td>109 2,108 56</td>
<td>14,386 24,219 0.56</td>
<td>1.14</td>
<td>80.95</td>
<td>680* 807</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>130 11,279 47</td>
<td>21.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 4704 m²</td>
<td>Bio Floc</td>
<td>16 (PW) 34 (PW)</td>
<td>257</td>
<td>1</td>
<td>85 1,962 93</td>
<td>17,963 38,229 0.58</td>
<td>1.12</td>
<td>86.54</td>
<td>680* 1,124</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>155 7,192 47</td>
<td>21.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 2,500 m²</td>
<td>Bio Floc</td>
<td>9 (PW) 36 (PW)</td>
<td>280</td>
<td>1</td>
<td>84 924 86</td>
<td>12,371 49,484 0.48</td>
<td>1.11</td>
<td>102.35</td>
<td>680* 1,031</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>155 6,177 50</td>
<td>20.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 2500 m²</td>
<td>Bio Floc</td>
<td>7 (PW) 28 (PW)</td>
<td>145</td>
<td>1</td>
<td>110 1,166 51</td>
<td>6,545 26,180 0.50</td>
<td>1.10</td>
<td>86.35</td>
<td>680* 655</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>127 5,012 47</td>
<td>21.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 2500 m²</td>
<td>Bio Floc</td>
<td>9 (PW) 36 (PW)</td>
<td>145</td>
<td>1</td>
<td>110 892 61</td>
<td>6,615 26,460 0.50</td>
<td>1.10</td>
<td>100.8</td>
<td>680* 551</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Final</td>
<td>130 5,400 54</td>
<td>18.52</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Performance - Shrimp Farms at Java & Bali, Indonesia using Biofloc Technology

Karang Asem, Bali, Indonesia

<table>
<thead>
<tr>
<th>Pond</th>
<th>A2</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond size</td>
<td>2,600m²</td>
<td>2,500m²</td>
<td>2,000m²</td>
<td>2,000m²</td>
<td>2,000m²</td>
<td>600m²</td>
<td>600m²</td>
<td>600m²</td>
</tr>
<tr>
<td>PL tebar</td>
<td>129/m²</td>
<td>134/m²</td>
<td>167/m²</td>
<td>167/m²</td>
<td>167/m²</td>
<td>152/m²</td>
<td>152/m²</td>
<td>152/m²</td>
</tr>
<tr>
<td>DoC</td>
<td>125</td>
<td>125</td>
<td>126</td>
<td>91*</td>
<td>125</td>
<td>147</td>
<td>135</td>
<td>147</td>
</tr>
<tr>
<td>SR %</td>
<td>91</td>
<td>84</td>
<td>93</td>
<td>62</td>
<td>85</td>
<td>92</td>
<td>89</td>
<td>91</td>
</tr>
<tr>
<td>FCR</td>
<td>1.3</td>
<td>1.42</td>
<td>1.36</td>
<td>1.45</td>
<td>1.44</td>
<td>1.61</td>
<td>1.52</td>
<td>1.58</td>
</tr>
<tr>
<td>Harvest/pond</td>
<td>6,232 kg</td>
<td>5,695 kg</td>
<td>5,645 kg</td>
<td>2,493 kg</td>
<td>5,248 kg</td>
<td>2,018 kg</td>
<td>1,725 kg</td>
<td>1,943 kg</td>
</tr>
<tr>
<td>Harvest/ha</td>
<td>23,969 kg</td>
<td>22,781 kg</td>
<td>28,225 kg</td>
<td>12,464 kg</td>
<td>26,235 kg</td>
<td>33,645 kg</td>
<td>28,750 kg</td>
<td>32,361 kg</td>
</tr>
</tbody>
</table>

Singaraja, Bali, Indonesia

<table>
<thead>
<tr>
<th>Pond</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond size</td>
<td>2,500m²</td>
<td>2,500m²</td>
</tr>
<tr>
<td>PL tebar</td>
<td>152/m²</td>
<td>152/m²</td>
</tr>
<tr>
<td>DoC</td>
<td>147</td>
<td>147</td>
</tr>
<tr>
<td>SR %</td>
<td>85</td>
<td>81</td>
</tr>
<tr>
<td>ABW</td>
<td>24.39</td>
<td>24.39</td>
</tr>
<tr>
<td>FCR</td>
<td>1.63</td>
<td>1.59</td>
</tr>
<tr>
<td>Harvest/pond</td>
<td>6,304 kg</td>
<td>6,005 kg</td>
</tr>
<tr>
<td>Harvest/ha</td>
<td>25,212 kg</td>
<td>24,020 kg</td>
</tr>
</tbody>
</table>

Java, Indonesia (Avnimelech 2009)

<table>
<thead>
<tr>
<th>Pond</th>
<th>D6</th>
<th>D5</th>
<th>D8</th>
<th>D7</th>
<th>D9</th>
<th>D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond size</td>
<td>115/m²</td>
<td>115/m²</td>
<td>141/m²</td>
<td>172/m²</td>
<td>176/m²</td>
<td>139/m²</td>
</tr>
<tr>
<td>PL tebar</td>
<td>113</td>
<td>121</td>
<td>118</td>
<td>121</td>
<td>121</td>
<td>108</td>
</tr>
<tr>
<td>DoC</td>
<td>85</td>
<td>106</td>
<td>77</td>
<td>79</td>
<td>53</td>
<td>75</td>
</tr>
<tr>
<td>SR %</td>
<td>16.7</td>
<td>15.36</td>
<td>17.3</td>
<td>17.89</td>
<td>20.08</td>
<td>15.5</td>
</tr>
<tr>
<td>FCR</td>
<td>1.37</td>
<td>1.6</td>
<td>1.51</td>
<td>1.75</td>
<td>2</td>
<td>1.65</td>
</tr>
<tr>
<td>Harvest/pond</td>
<td>8,214 kg</td>
<td>7,374 kg</td>
<td>8,566 kg</td>
<td>6,739 kg</td>
<td>5,256 kg</td>
<td>7,533 kg</td>
</tr>
<tr>
<td>Harvest/ha</td>
<td>16,300 kg</td>
<td>18,700 kg</td>
<td>18,500 kg</td>
<td>14,600 kg</td>
<td>11,400 kg</td>
<td>16,400/kg</td>
</tr>
</tbody>
</table>

Based on report from Suri Tani Pemuka, Indonesia
Bio-floc in Raceways/Wet Lab Experiments, Trials & Growout

1. Nursery–nursed for 1 to 2 weeks then to GO
2. Super-intensive /intensive culture (to market size)
4. Broodstock testing– trials for quality of broodstock family lines (two to four months).
5. First phase of the three phase culture system.
## Raceway Technology
### Biofloc Trials - Nursery & GO

<table>
<thead>
<tr>
<th>Description</th>
<th>Stocking Density (pcs/m²)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>550</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Pond</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Initial MBW (g)</td>
<td>4.9</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Period (days)</td>
<td>57</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Harvest Biomass (kg)</td>
<td>374</td>
<td>151</td>
<td></td>
</tr>
<tr>
<td>Final MBW (g)</td>
<td>13.8</td>
<td>18.4</td>
<td></td>
</tr>
<tr>
<td>FCR</td>
<td>1.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>66</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>ADG (g/day)</td>
<td>0.16</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Productivity (kg/m²)</td>
<td>5.2</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Productivity (kg/ha)</td>
<td>51,893</td>
<td>21,001</td>
<td></td>
</tr>
</tbody>
</table>
Raceway trials in BFT

Global Group Raceways at Anyer, Indonesia

The raceway system with biofloc is being applied for trials for *L. vannamei* broodstock family selection.
Wet Laboratory – Trial Tanks

Global Group facility at Anyer, Indonesia

1. Shrimp feed trials using transferred Biofloc
2. Small scale experiments at request
3. Freshwater tolerance experiments
4. Nursery stage experiments
Potential of BFT – PERU
Lined and covered

Piura - Intensive with freshwater covered

Piura - Inside covered pond

Piura-Intensive FW Nursery

Tumbes-Extensive with SW

Grain
Potential for BFT – GUATEMALA
Lined with high energy input
Potential for BFT – CHINA
Lined, covered & high energy input
Potential for BFT – Malaysia
Ideal layout and bio-secured

Well designed farm layout

Seawater Intake – 2.6 km offshore

Biosecurity in place
Advantages/ Disadvantages

Advantages

1. Bio-security very good (from water) – to date WSSV negative using the system.
2. Zero water exchange – less than 100% exchange for whole culture period.
3. Production (Carrying capacity): 5-10% better than normal system
4. Shrimp size bigger by about 2.0 g than normal system
5. FCR low – between 1.0 to 1.3 (without GP)
6. Production cost lower by around 15-20%.

Disadvantages

1. High energy input – paddlewheels 28HP/ha.
2. Power failure critical – maximum one hour at any time (better zero hour failure)
3. Full HDPE lined ponds – minimum semi-HDPE lined
4. Technology similar but more advance – need to train technicians
According to Shrimp News International (2006) No one knows how many shrimp farms are employing the bio-floc technology. The best examples of the farms that have implemented the new technology are: 1. Belize Aquaculture, Ltd., in Belize. 2. OceanBoy Farms in Florida, USA, and 3. PT Central Pertiwi Bahari in Indonesia.
SHRIMP PRODUCTION IMPROVEMENT

Sergio Nates Dec 2006
Thank You

Nyan Taw
References


McIntosh, Robin P., 2000a Changing paradigms in shrimp farming. III Pond design and operation consideration *The Advocate* February 42-45


McIntosh, Robin P., 2000c Changing paradigms in shrimp farming. V Establishment of heterotrophic bacterial communities *The Advocate* December 52-54


