Biofloc Technology has become a popular technology in the farming of Pacific white shrimp, *Litopenaeus vannamei*. The basic technology was developed by Dr. Yoram Avnimelech in Israel and initially implemented commercially in Belize by Belize Aquaculture. It also has been applied with success in shrimp farming in Indonesia and Australia. The combination of two technologies, partial harvesting and biofloc, has been studied in northern Sumatra, Indonesia.

**Biofloc Technology**

Biofloc is defined as macroaggregates composed of diatoms, macroalgae, fecal pellets, exoskeleton, remains of dead organisms, bacteria and invertebrates. It is possible this microbial protein has a higher availability than feed protein.

The basic requirements for biofloc system operation include high stocking density, high aeration and lined ponds. Pelleted grain and molasses are added to the culture water. A crucial factor is biofloc control during operation.

Biofloc systems deliver high productivity with sustainability. Also, with viral problems and rising costs for energy, biofloc technology can help deliver sustainable production at lower cost.
Commercial Interest

Commercial interest in biofloc technology is threefold, for bioflocs provide high productivity, low feed-conversion ratios (FCRs) and a stable culture environment. Also, with emerging viral problems and rising costs for energy, biofloc technology appears to be an answer for sustainable production at lower cost.

The technology has not only been applied at commercial shrimp growout farms, but also in super-intensive raceways to produce more than 9 kg shrimp/m³. The raceway applications have supported nursery and growout to shrimp broodstock rearing and selection of family lines. Presently, a number of studies by major universities and private companies are using biofloc as a protein source in shrimp and fish feeds.

Applications

The number of shrimp farms currently using biofloc technology is not known, but some prominent examples are Belize Aquaculture, Ltd., in Belize and P.T. Central Pertwi Bahari in Indonesia. The success or failure of the technology is mainly due to the degree of understanding of basic concepts of the technology in commercial application.

Belize Aquaculture was the first commercial farm to use biofloc technology successfully. Its production of 13.5 mt shrimp/ha was quite an achievement at the time. The Belize technology was applied initially in Indonesia at C.P. Indonesia (now P.T. Central Pertwi Bahari, C.P. Indonesia), which achieved average production over 20 mt/ha in commercial 0.5-ha lined ponds. Research trials reached 50 mt/ha.

The technology combined with partial harvest was repeated in Medan, Indonesia, with better results. During 2008 and 2009, biofloc technology was used in Java and Bali successfully. In Indonesia, biosecurity protocols were incorporated within the technology.

Most Indonesian shrimp farmers are interested in biofloc technology, but with some reservations, as a number of projects have failed due to incomplete understanding of the technology. For example, the correct number and position of paddlewheel aerators used in ponds are essential.

The main objectives for paddlewheel aerators are to keep bioflocs in suspension. This can be achieved with informal aeration, but with no mechanism to concentrate solid waste for removal, high levels of suspended biofloc biomass can lead to deterioration of pond water quality. Even-

### Table 1. Performance of shrimp farms in Bali, Indonesia, using biofloc technology.

<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>
<th>B4</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>2,600 m²</td>
<td>2,500 m²</td>
<td>2,000 m²</td>
<td>2,000 m²</td>
<td>2,000 m²</td>
<td>600 m²</td>
<td>600 m²</td>
<td>600 m²</td>
<td>2,500 m²</td>
<td>2,500 m²</td>
</tr>
<tr>
<td>Stocking density</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>
<td>152/m²</td>
<td>152/m²</td>
</tr>
<tr>
<td>Days of culture</td>
<td>125</td>
<td>125</td>
<td>126</td>
<td>91*</td>
<td>125</td>
<td>147</td>
<td>135</td>
<td>89</td>
<td>147</td>
<td>147</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>91</td>
<td>84</td>
<td>93</td>
<td>62</td>
<td>85</td>
<td>92</td>
<td>89</td>
<td>85</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Feed-conversion ratio</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>
<td>1.63</td>
<td>1.59</td>
</tr>
<tr>
<td>Harvest/pond</td>
<td>6.23 mt</td>
<td>5.69 mt</td>
<td>5.64 mt</td>
<td>2.49 mt</td>
<td>5.25 mt</td>
<td>2.02 mt</td>
<td>1.72 mt</td>
<td>1.94 mt</td>
<td>6.30 mt</td>
<td>6.00 mt</td>
</tr>
<tr>
<td>Harvest/ha</td>
<td>23.97 mt</td>
<td>22.78 mt</td>
<td>28.22 mt</td>
<td>12.46 mt</td>
<td>26.23 mt</td>
<td>33.64 mt</td>
<td>28.75 mt</td>
<td>32.36 mt</td>
<td>25.21 mt</td>
<td>24.02 mt</td>
</tr>
</tbody>
</table>
ually, this results in premature harvests, if not total crop failure.

Advantages, Disadvantages
The advantages of biofloc technology include very high bios-
security. To date, white spot syndrome virus has not been a factor
in the systems. Production and carrying capacity are typically 5
to 10% higher than in typical culture systems, with zero water
exchange. Shrimp grow larger and reflect feed-conversion
rations between 1.0 to 1.3. Production costs can be 15 to 20%
lower.

The disadvantages include high energy inputs for aerators.
Power failures over an hour in duration can be critical. Biofloc
ponds must be lined. The more advanced technology also
demands a greater need to properly train technicians.

Growing Interest
Due to success stories in Indonesia and the United States,
many shrimp farmers are interested in biofloc technology. The
Indonesia Department of Fisheries and shrimp associations are
arranging a three-day training workshop on biofloc in Indonesia.
Dr. Yoram Avnimelech was invited to lead the workshop in April.

In China, a number of shrimp farmers are also interested.
Their fully HDPE-lined, plastic-covered shrimp growout ponds
with high-density culture are ideal for the technology. The
author is currently advising shrimp farms with HDPE-lined
intensive culture ponds in Central America on biofloc systems.
A group from Brazil is running commercial biofloc trials.

Malaysia is currently initiating a 1,000-ha integrated inten-
sive shrimp-farming project at Setiu, Terengganu by Blue
Archipelago. The company also plans to use the technology.