Underwater Sound Analysis Technology applied to Monitor Shrimp Feeding Behavior & Adjust Feeding Strategy

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Specifities of shrimp farming in terms of feeding strategy & efficiency

✓ Shrimp is almost the only animal grown in the world which doesn’t let being seen by its grower.

✓ Farmers grow shrimp by millions, in turbid waters, distributing them thousands (or even millions) of dollars of feed, without being sure that’s adapted in quantity and timing shrimp need.

✓ Feed is the major production cost, but it is distributed blindly!
Existing Shrimp Feeding Strategy

In-lab estimated daily feed intake in % of Body Weight

Estimated cumulated FCR based on biomass estimation

Test feeding trays
Existing Shrimp Feeding Delivery Methods

By hand + feed tray

Blower + feed tray

Use of Auto feeders increasing but still require feed tray and estimate future shrimp feed requirements
Factors that impact daily feed consumption

- Water Temperature
- Oxygen
- Feed composition
- Moon phase
- Variation of shrimp size/size distribution
- Barometric pressure
- Predators
- Timing of Feeds
- Behaviour
- Chemical composition of water
- Health
  - etc...

Combination of factors make it impossible to predict exactly how much to feed and when. Must use sensor based feeding control systems to optimize production performance.

To meet the feed requirements of fish or shrimp, without waste, Feeding Control Systems require two key technologies:
1. Adaptive Feeding Algorithm

2. Sensor to Detect Feeding Rate
Need for Feeding Control Technology

- Feeding and management of feed trays is a **significant cost**
- Changed environmental and physical conditions can lead to significant **variation in meal to meal and daily feed intake**
- Measuring actual **instantaneous intake** is **critical** to shrimp growth (avoid under/over feeding) and pond health (by avoiding waste).
- Improve/replace current practice (ie: feed trays) that have inherent inadequacies
  - **pellet loss due to handling**
  - **subjective** feed tray analysis
  - non instantaneous measure – miss the feeding window
- Food intake is a key indicator of pond/health status or biological issues (moulting, pellet palatability, disease etc.)
Need for Feeding Control Technology

✓ Automatically target the period when feeding is at its most active
✓ Instant feeding data so response to issues such as disease, moulting or pond deterioration is immediate
✓ Traditional feeding practice often leads to extended feeding periods and pellet deterioration. Estimated 12% dry matter loss in 4hr and N leaching 7% - 30 min, 12% - 1hr and 15% - 2hr (Smith et. al. 2002).

Fig. 1. Loss of N through leaching from feed pellets over time.
SF200 - Sound Feeding System

System Components

- Hydrophone
- SF200 Controller
- DO/Temp Probe
- Management Software
- Environ alarms

REAL TIME FARM MANAGEMENT INFORMATION

SF200 Analysis Software
Feeding Control and Environmental Monitoring

INTERNET

Radio Base Station

Control Office
Sound Feeding Technology

How it works

- Detection and differentiation of feeding sounds as opposed to other pond generated sound
- Feeding sounds in the 1-20kHz range
- Complex and proprietary Adaptive® shrimp feeding algorithms to self regulate intake
- So far developed for *P. monodon* (black tiger), *M. japonicus* (kuruma), *L. vannamei* (white) & *L. stylirostris* (blue)
- 4 years in testing and development
- Strong relationship between sound activity and feed intake ($R^2 = 0.8236$)
- Use of feed tray to “ground truth” system
Feeding Control System Development

**Background**

- Development of passive acoustic feeding control commenced 2007
- > 3,000 days recording shrimp feeding in 10 countries
- 6 species of shrimp with sizes ranging from 1 gram to 43 grams
- Recordings taken in ponds 0.1 ha to 10 ha
- Feed trays and underwater cameras used to correlate acoustic data
- Initial trial on *P. monodon* in 2009/10 season
- Multiple production trials on *L. vannamei* & *P. monodon* in 2010-11 & *L. stylirostris* in 2012

Feed response Black Tiger fed with feed cannon (Australia)

Feed response *vannamei* hand fed with feed trays (Panama)

Feed response Black Tiger fed with auto feeder (Thailand)
Identifying and quantifying the *L. vannamei* feeding signature at Auburn University, USA
Instantaneous feed response

*L. vannamei*

*P. monodon*
Sound Feeding System (SF200) Controls Auto-feeders

Thai feeders with single or three phase circular spreaders
SF200 – Production Trials in 2010, 2011 & 2012

Trial Aims

• Confirm identification and quantification of shrimp feeding sounds

• Test adaptive feeding control algorithms which automatically adjusts temporal feed delivery to match shrimp appetite and feeding rate

• Determine the natural feeding pattern of shrimp and feed to appetite over the 24-hour cycle

• Investigate change in environmental conditions on feed intake

• Determine whether this feeding control approach produced beneficial FCR, growth and total harvested biomass

ALL of these trials have been realized in private farms (real conditions)
**P. monodon** Farm Production Trials
Gold Coast Marine Aquaculture, Australia

- Jacobs Well, SE Queensland, Australia
- **P. monodon**
- x53 -1ha ponds and several 0.3 ha ponds
- Annual production ~600-800 mt
- Use CP and Ridley Aquafeed pellets
- 1 crop per year
- Salinity range 20-40 ppt
- Temperature range 20-30°C
Trial 1 2009/10: SF200 in Commercial *P. monodon* Pond

- 2 x 0.38 hectare lined ponds
- SF200 and single 12VDC Auto Feeder with 10m diameter feed spread
- Stocked in 25\textsuperscript{th} Sept 2010;
- SF200 pond – 140,000 PLs
- 47PLs/m\textsuperscript{2}
Trial 1 2009/10: SF200 in Commercial *P. monodon* Pond

**Result #:1**

Strong reduction of feed intake during synchronized moulting phases
Result #2:
Strong reduction of feed intake during and just after heavy rains.
Trial 2 GCMA 2010/11 - SF200 on *P. Monodon* in 1 ha Ponds

- 1 hectare ponds
- Pond 1 - SF200r/ 4 auto-feeders
- Control (compared to Cannon Fed with feed trays)
- Both stocked in 25\textsuperscript{th} Sept 2010;
- SF200 pond – 392,000, Blow-Fed 368,000 PLs each

![Diagram of 1 hectare pond layout with four auto-feeders located at corners and central point.](image-url)
GCMA Trial #2:
Variation in feeding activity, dissolved oxygen and water temperature over one typical day.
GCMA Trial #2:

Result #1:
• preference of **night feed intake** during **warm season**
GCMA Trial #2:

Result #2:
Preference of feed intake in same pond spread to day time also in cold season
Feed control - Feeder output in relation to wind and position

**Feeder Output (%) V's Time**

<table>
<thead>
<tr>
<th>Wind Quarter</th>
<th>Occurrence</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>49</td>
<td>19%</td>
</tr>
<tr>
<td>E</td>
<td>113</td>
<td>45%</td>
</tr>
<tr>
<td>S</td>
<td>84</td>
<td>33%</td>
</tr>
<tr>
<td>W</td>
<td>6</td>
<td>2%</td>
</tr>
</tbody>
</table>
GCMA Trial #2:

Trial – SF200 vs Cannon feed from truck

<table>
<thead>
<tr>
<th>Pond</th>
<th>Density (Stocked)</th>
<th>DOC</th>
<th>MBW (Grams)</th>
<th>Survival</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blow-Fed 4 x daily</td>
<td>38</td>
<td>197</td>
<td>37</td>
<td>73</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>368,000 PL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF200</td>
<td>40</td>
<td>195</td>
<td>40</td>
<td>75</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>392,000 PL</td>
<td></td>
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</tr>
</tbody>
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Avge Prawn Wgt (g)

Truck with Blower

SF200

Farm Gate Profit Per Pond Per Crop (A$)

Current Method

SF200

Payback of 1.5 times in one crop

Australia - monodon
L. Vannamei Trial 2011 – Thailand

- Tawee Shrimp - Surat Thani, Thailand
- 200 x 1 ha ponds
- 3 Replicate Ponds x 3 Treatments
- SF200 Vs Auto Feeder Vs Hand Fed
- CP feed & PLs
- 90-100 PL/m²
- 2 crops per year
- Salinity range 12-20 ppt
- Temperature range 24-30°C
Tawee - diurnal variation in feeding activity, temperature & DO
Feed Rate & Response
6-8 Dec 2011

Orange line on the 3 graphs shows feeding activity across a 72 hour period.
**L. Vannamei** Trial 2011 – Thailand

Replicate Trial – 3 ponds per method

SF200 vs Hand Feeding vs Semi Auto Feeder

Payback 2 times in 1 crop or 4 times per year
L. stylirostris Farm Production Trial
Styliblueue in New Caledonia

- La Foa, New Caledonia
- L. stylirostris
- x2 -8ha ponds stocked at 25 PLs/m2
- Annual production ~60-80 mt
- Use SICA-NC local feed pellets
- 1 crop per year
- Salinity range 30-40 ppt
- Temperature range 20-33°C
L. stylirostris Farm Production Trial
Styliblueue
**L. stylirostris** Farm Production Trial, Stylibleue

Same population but different feeding quantities & times

- 669 kg Jan 05
- 604 kg Jan 06
- 625 kg Jan 10
New Species and Grow Out Method

Vietnam (L. vannamei): 0.36ha pond at 180 PLs/m²

Saudi Arabia (F. indicus): 10ha pond at 22 PLs/m²

New Caledonia (L. stylirostris): 7.6ha pond at 25 PLs/m²
Sound Feeding System (SF200) Performance Overview

Commercial trials on *P. monodon* and *L. vannamei* during 2010 and 2011 showed the System:

- Analyses and quantifies instantaneous feeding rate
- Controls feed delivery rate to feed to appetite or ration without waste 24/7
- Measures feeding activity continuously cf. feed tray every 2-3 hours.
- Improves Feed Conversion & **Growth**
- Reduces labor cost per kg
- Monitors and alarms key environmental parameters - DO, temperature, power
- Delivered an excellent Return on Investment in all trials
It’s time to let us decide how much & when we eat! We will grow quicker and you will be happier...

Thank you