Economics of Best Management Practices (BMPs) for Aquaculture

Carole R. Engle
UAPB Aquaculture/Fisheries Center
Many different types of policies have been developed and implemented.

- Contrast BMPs with other types of environmental policies; and
- Review literature on economics of BMP use in aquaculture
Environmental policies and implementation are diverse and complex

- Point sources vs. non-point sources
- Command-and-control vs. incentive-based
- Direct vs. indirect effects
- Affect costs of production or quantity of pollution discharged
<table>
<thead>
<tr>
<th>Command &amp; Control</th>
<th>Incentive-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission charges &amp; standards</td>
<td>Taxes (discharges or inputs)</td>
</tr>
<tr>
<td>Discharge permits</td>
<td>Performance bonds/deposits</td>
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<tr>
<td>Load limits, quotas</td>
<td>Subsidies, compensation</td>
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<tr>
<td>Minimum nutrient conc.</td>
<td>Tradeable emission permits</td>
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<td>Mandatory production practices</td>
<td>Voluntary agreements</td>
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<tr>
<td>BMPs</td>
<td>BMPs</td>
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## Examples

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
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<tbody>
<tr>
<td>Tax on discharge</td>
<td>Tax on inputs</td>
</tr>
<tr>
<td>Emission charges, standards</td>
<td>Zoning</td>
</tr>
<tr>
<td>Load limits, quotas, permits, min. nutrient conc.</td>
<td>Subsidies, compensation</td>
</tr>
<tr>
<td>Performance bonds/deposits</td>
<td>Mandatory production practices, feed consumption standards</td>
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<tr>
<td>Limits on non-native species, restrictions on drugs &amp; chemicals</td>
<td>Voluntary agreements, Codes of Conduct</td>
</tr>
<tr>
<td>BMPs</td>
<td>BMPs</td>
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<tr>
<td>Cost of Production</td>
<td>Quantity</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------------------------------------</td>
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<tr>
<td>Emission charges</td>
<td>Quotas, direct load limits, max. nutrient conc.</td>
</tr>
<tr>
<td>Taxes (discharge &amp; inputs)</td>
<td>Emission standards and permits (tradeable &amp; untradeable)</td>
</tr>
<tr>
<td>Performance bonds/deposits</td>
<td>Limitations on non-native species</td>
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How & Why did BMPs Start in the U.S.?

• Introduced in U.S. in 1970s in response to concerns over agriculture as NPS

• Traditional approach defines BMPs as cultural practices that reduce soil & nutrient loss at reasonable cost.

Intended as GREEN: GOLD option.
Why BMPs? (Best Management Practices)

- History of successful use in agriculture and forestry.
- Positive cooperation rather than more regulations.
- Flexible --- can be tailored to species, updated to fit new production methods.
The diagram illustrates a relationship between environmental impacts and costs, aiming to minimize both. The least costs solution is marked with a blue circle, indicating the optimal balance between minimizing costs and environmental impacts. The unattainable solution corresponds to the optimal of both objectives. Additionally, the least environmental impacts solution is also highlighted, showing an alternative perspective in optimizing environmental outcomes while considering costs.
Farmer Adoption of BMPs: research from other crops

- Growers preferred BMPs w/proven track record, low tech, easy to operate & maintain.
- BMPs that result in optimal input use adopted more rapidly.
- Insurance policies can help adoption.
BMP Cost Categories

- Structural: Investment
- Management: Operating Costs
Examples of BMPS applied or proposed for aquaculture

<table>
<thead>
<tr>
<th>Country</th>
<th>Species</th>
<th>Production system</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>Catfish</td>
<td>Ponds</td>
</tr>
<tr>
<td>U.S.</td>
<td>Hybrid striped bass</td>
<td>Ponds w/water exchange</td>
</tr>
<tr>
<td>U.S.</td>
<td>Trout</td>
<td>Raceways</td>
</tr>
<tr>
<td>U.S.</td>
<td>Salmon</td>
<td>Net pens</td>
</tr>
<tr>
<td>Honduras, Nicaragua</td>
<td>Shrimp</td>
<td>Ponds</td>
</tr>
<tr>
<td>Thailand</td>
<td>Shrimp</td>
<td>Ponds</td>
</tr>
</tbody>
</table>
What are Effluents of Concern from Pond Aquaculture?

• Nutrients (Nitrogen, Phosphorus)
• Settleable solids (especially from harvesting during draining)
• Oxygen demand from organic matter
Lists accumulation of problematic nutrients in the Gulf of Mexico:

- Nitrogen
- Phosphorus
- Silicon

“Sediments from increased river nutrients is the principal cause...”
(Council for Agricultural Science and Technology 1999).

Zone without oxygen in Gulf of Mexico has been increasing in size.
Catfish Ponds not Drained for 7-15 Years; 75% of Production Cost in Waste Treatment

Engle and Valderrama (2002)
Settling basins:

- Increased investment capital requirements
- Affected cash flow
- Decreased net returns above total costs by 66% and 20% for small and medium farms.

Thongrak et al. (1997)
Brennan (2002)
Engle & Valderrama (2003)
Hybrid Striped Bass

- Settling basins economically infeasible
- Filtering options assessed economically infeasible
- Reducing water exchange improved profits, but commercial verification of long-term effects needed.

Valderrama and Engle (2004) developed LP model to evaluate five BMP components to reduce effects of effluents for Honduran farms

- Reduction of water exchange rates
- Reduction of production levels
- Use of feed trays
- Settling basins for last 10% of discharge
- Partial recirculation of effluents through mangrove biofilter.
Phosphorus (total) net discharges

- Small farm
- Medium farm
- Large farm

- Base scenario
- Reduced water exchange to 5%
- 5% volume, initial standards
- 5% volume, target standards
- 2% volume, initial standards
- 2% volume, target standards
- Feed trays
- Settling basins

kg/farm/day
Net returns for shrimp farms with different effluent treatment options

- **Base scenario**
- **Low exchange**
- **W/low source TP**
- **W/high source TP**
- **Feed trays**
- **Settling basins**
- **Natural mangroves**
- **Constr. mangroves**

$ (U.S.)$
Mangrove Biofilters:

- Most expensive treatment option
- Innovative approach
- Appealing from environmental perspective, but not currently feasible economically
Effect of imposing limits on net discharge from farms

• Forcing farms to reduce discharge to a 2% water exchange rate caused changes in the management plan.
• June stockings were reduced; March stockings increased.
• Results sensitive to nutrient conc. in initial water supply.
Flow-through systems:
Effluent treatment options considered by USEPA.

1. Quiescent zones, settling basins, & BMPs for TSS.
2. All of Option 1 + BMPs for drug & chemical treatment.
3. All of Option 2 + solids polishing w/microscreen filters & weekly compliance monitoring for TP.
### Net Returns from Trout After Imposing Effluent Treatments

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NC med.</th>
<th>ID med.</th>
<th>ID. Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>$8,644</td>
<td>$5,647</td>
<td>$284,281</td>
</tr>
<tr>
<td>Option 1</td>
<td>-$25,509</td>
<td>-$33,810</td>
<td>$43,087</td>
</tr>
<tr>
<td>Option 2</td>
<td>-$27,180</td>
<td>-$35,469</td>
<td>$41,427</td>
</tr>
<tr>
<td>Option 3</td>
<td>-$32,320</td>
<td>-$39,879</td>
<td>$35,573</td>
</tr>
</tbody>
</table>

Engle et al. (2005)
## Probability of being profitable

<table>
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<th></th>
<th>NC-med.</th>
<th>ID-med.</th>
<th>ID-large</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base</strong></td>
<td>46%</td>
<td>2%</td>
<td>84%</td>
</tr>
<tr>
<td><strong>Option 1</strong></td>
<td>0%</td>
<td>0%</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Option 2</strong></td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Option 3</strong></td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
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Mathematical Programming
Model Results

• Demonstrated high level of sensitivity to levels of access to capital for both operating and investment.

• No effluent treatment options were feasible at levels of investment estimated.

• Subsequent runs used 50% of estimated capital requirements for effluent treatment options.
Imposing effluent treatment options into model:

- Forced farms to substitute production units for effluent treatment due to:
  - Capital requirements for treatment
  - Limited access to capital
  - Competing uses for land in trout farming areas driving land prices upwards.
Net pens:

- Active feed monitoring
  - Minimize uneaten feed accumulation beneath nets
- Proper disposal of feed bags,
- Limit waste discharge during harvest & transport
- BMPs for non-native species.

Individual tags:
30% reduction in production capacity
CONCLUSIONS

• BMPs targeted at improving production efficiency had largest potential to reduce net discharges and increase profit margins = **Green – Gold**

• Careful evaluation of BMPs essential

• **Devil’s in the details!**

• Non-economic factors important in adoption
QUESTIONS???