Building a Better Hatchery:
Culturing Oysters (*Crassostrea virginica*) in a High-Density Recirculating System

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Background: Oyster Aquaculture

Rapidly growing industry

Requires:
- Large number of workers
- Large and expensive equipment
- Consistent supply of oyster seed and larvae

Supply provided by hatcheries

Congrove, 2012; Kamermans, 2016; Merino, 2009
Background: Hatcheries

Produce seed and larvae for industry

Relies on good ambient water quality
  • Inconsistent and unpredictable
  • High mortality and shortages
  • Loss of profit

Research into systems providing:
  • High yield
  • Fast development
  • Consistent
  • Cost-effective

Congrove, 2012; Kamermans, 2016; Merino, 2009
Background:
The Oyster Life Cycle

https://static1.squarespace.com/static/525407e8e0608645f8b1a539/53a9b407e06b5c3019e4f0b0/14536304115/
Background: The Static System (SS)

Traditional setup

Large tanks of non-flowing water with periodical water changes

Benefits:
- Low upkeep
- Less water

Setbacks:
- Large equipment
- Larvae stressed during draining
- Variability in water quality
- Low product yield

(Congrove, 2012; Kamermans, 2016; Merino, 2009)
Background: The Flow-Through System (FTS)

Increasingly common setup

Circulation of flowing water through tanks without removing larvae

Benefits:
• Reduced equipment size
• Reduced waste and food supply
• Increased survivability

Setbacks:
• High upkeep
• Large amount of water needed
• Variability in water quality

(Congrove, 2012; Kamermans, 2016; Merino, 2009)
Background: The Recirculating System

An uncommon setup

Set amount of water recirculates through filters without removing water or larvae

Benefits:
  • Reduced equipment size
  • Consistent water quality
  • Increased survivability
  • High product yield

Setbacks:
  • High upkeep

(Congrove, 2012; Kamermans, 2016; Merino, 2009)
Background: The Recirculating System

Guided by similar designs and past attempts (Congrove, 2012)
- Appropriate filters
- Duration of recirculation
- Duration and intensity of water flow
- Water chemistry

(Congrove, 2012)
Questions

• Can we construct a functioning high-density RAS?
• Will larvae survive to metamorphosis in the RAS?
• What do survivability and growth compare in RAS vs SS?
• Is the RAS cost-effective?
Methods: Procedure

• Oyster embryos reared in SS for 6 days (~100 mm length)
• Half of the larvae transferred to RAS, half retained in SS for comparison
• Larvae cultured in systems for up to 18 days
  • Water drained from SS every 2 days
  • Larvae sampled from both systems every 2 days for count
  • Water sampled from both systems daily to track water quality

(Congrove, 2012; Kamermans, 2016; Merino, 2009)
Methods: Procedure

• Examine effect of flow rate in RAS on survivability of larvae
  • Goal 10-20 cycles/day (11.5-23.1 mL/s)
  • Initial flow rate 20 cycles/day Week 1
  • Decrease flow rate to 15 cycles/day Week 2
  • Decrease flow rate to 10 cycles/day Week 3

(Congrove, 2012)
Methods: Analysis

• If culture is successful, perform calculations:
  • Survivability (%)
  • Change in growth (mm)
  • Proportion of eyed larvae (%)
  • Cost-effectiveness of design (time and price)

• If culture is unsuccessful, adjust design

• Survivability and growth of larvae in the RAS vs SS will be compared using a series of t-tests
Methods: Static System Design
Methods:
Recirculating System Design 1
Methods: Recirculating System Design 1

Setbacks:
- Valves require precise adjustment
- Difficult to maintain equal water flow

Solution:
- Replace manual valve with float valve
Methods:
Recirculating System Design 2

- RESEVOIR
- BIOFILTER
- FLOAT VALVE
- SCREEN
- LARVAL TANK
- MANUAL VALVE
- PUMP
- CARBON FILTER
- OVERFLOW TANK
Methods: Recirculating System Design 2

Benefits:
• Float valve automatically adjusts water flow

Setbacks:
• Float valve diminishes overall water flow

Solution:
• Eliminate second valve
• Reduce number of tanks
• Suspend larval tank above reservoir
Methods:
Recirculating System Design 3
Methods: Recirculating System Design 3

Benefits:
- Simplified design
- Single valve

Setbacks:
- Pump malfunctions
- Screen malfunctions
- Larvae escaping

Solution:
- Add overflow hose
- Add overflow screen
- Improve screen structure
- Seal loose connection
Methods:
Recirculating System Design 4
Methods: Recirculating System Design 4

Benefits:
- Improved pump
- Improved screen
- Repaired connection

Setbacks:
- Unknown
Results

- Can we construct a functioning high-density RAS?
- Will larvae survive to metamorphosis in the RAS?
- What do survivability and growth compare in RAS vs SS?
- Is the RAS cost-effective?
Results: Cost Analysis

Cost Difference
- Cost of SS construction alone ($5,500)
- Cost of SS 2-week operation ($700)
- Cost of RAS construction alone ($6,100)
- Cost of RAS 2-week operation ($300)

Profit Difference
- Larvae sell at $300/1 mill
- Projected profit of SS at 1.8 mill larvae (-$125)
- Projected profit of RAS at 18 mill larvae ($5,000)
Conclusion: Discussion

• RAS never reached completed stage
• RAS designs have slightly higher projected expense than SS
• RAS designs have much higher projected profit than SS
• Further research required
Hatcheries
They’re Hard to Build

• CONGROVE, M. 2012. Feasibility of a recirculating aquaculture system for early larval culture of *Crassostrea virginica*. Oyster Seed Holding, Inc., VA, USA.
