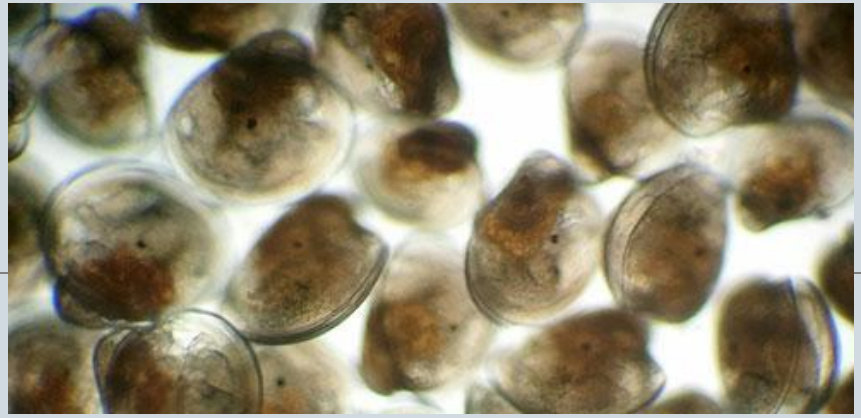
Building a Better Hatchery:

Culturing Oysters (*Crassostrea virginica*) in a High-Density Recirculating System



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PEARL INTERNSHIP PROGRAM

SUMMER 2017

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

http://www.notabletravels.com/wp-content/uploads/2014/07/Eel-Lake-Oyster-Farm-oysters-Nova-Scotia.jpg

http://maggiesfarm.anotherdotcom.com/uploads/oysteraqua.jpg

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:

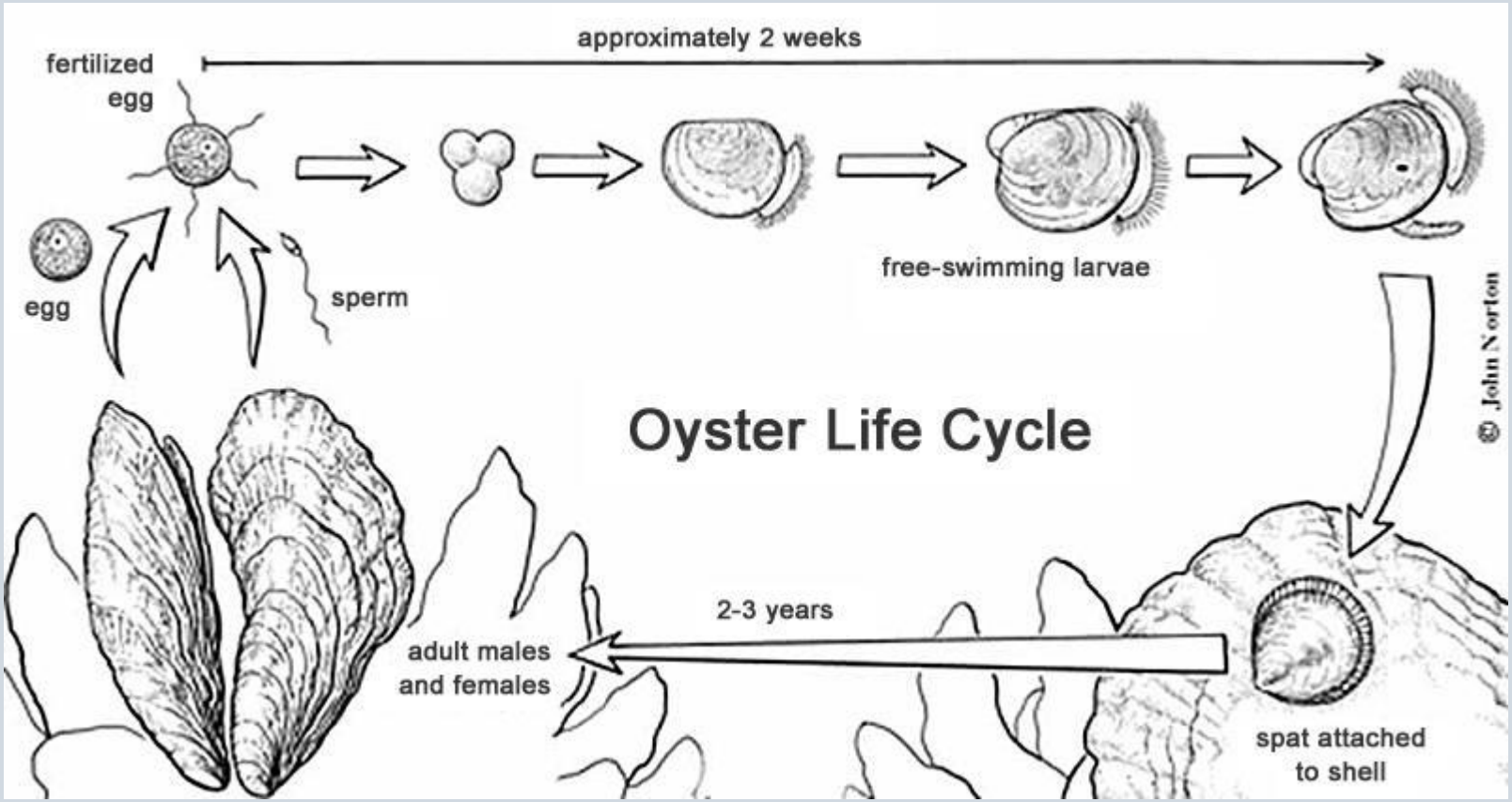
- High yield
- Fast development
- Consistent
- Cost-effective

Congrove, 2012; Kamermans, 2016; Merino, 2009

http://farm6.staticflickr.com/5467/6927064012_0ba21f36a8.jpg

http://oysterseedholdings.com/yahoo_site_admin/assets/images/pic5.310194339_std.jpg

Background:
The Oyster Life Cycle



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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)

http://www.bio.uib.no/bergenmarine/silony.jpg

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)

http://coastalshellfish.com/wordpress/wp-content/uploads/hatchery_tanks.jpg

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)

https://matiss.com/wp-content/uploads/2014/03/Recirculating-Aquaculture-System-2.jpg

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

https://matiss.com/wp-content/uploads/2014/03/Recirculating-Aquaculture-System-2.jpg

(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

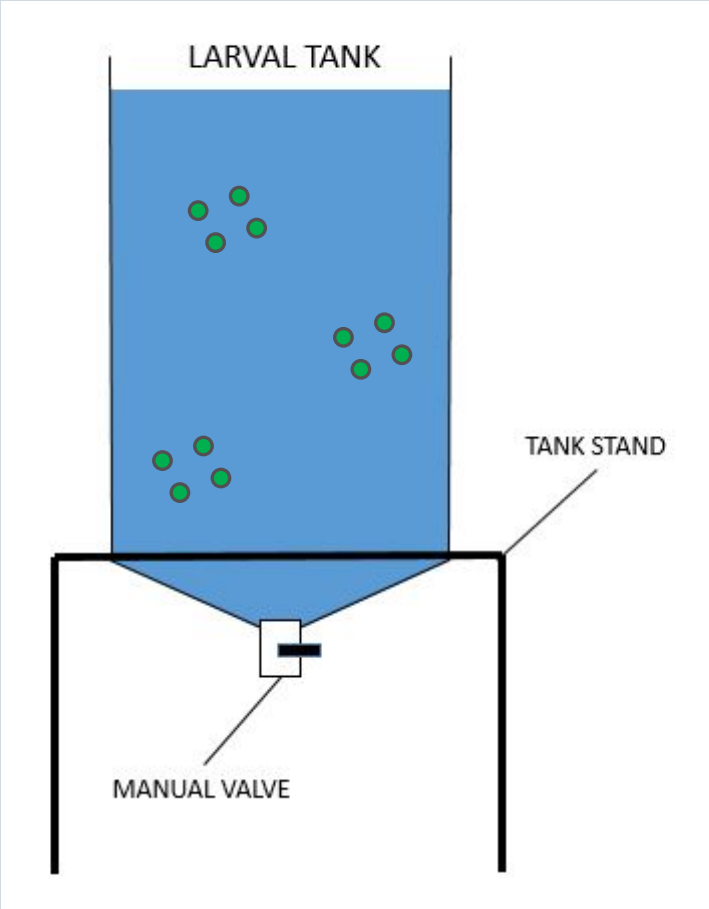
- Examine effect of flow rate in RAS on survivability of larvae
  - Goal 10-20 cycles/day (11.5-23.1 mL/s)
  - Initial flow rate 20 cycles/day Week 1
  - Decrease flow rate to 15 cycles/day Week 2
  - Decrease flow rate to 10 cycles/day Week 3

(Congrove, 2012)

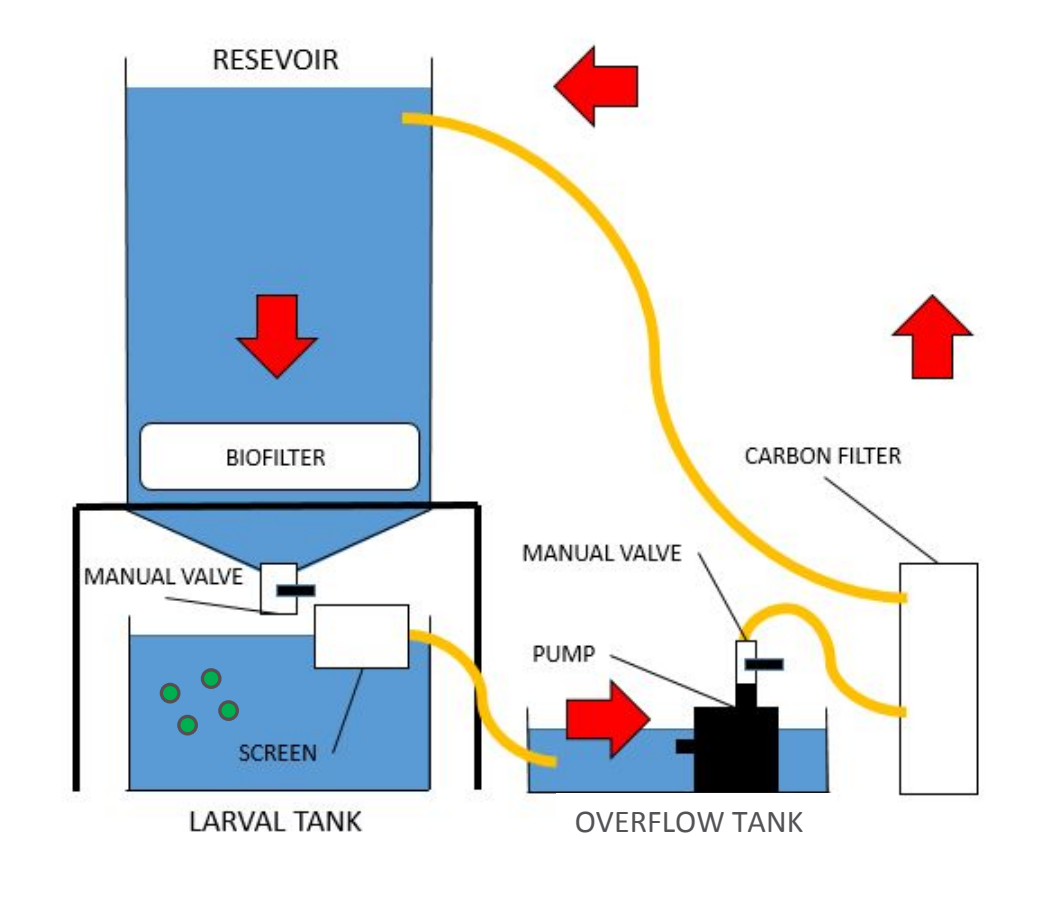
Methods:
Analysis

- 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



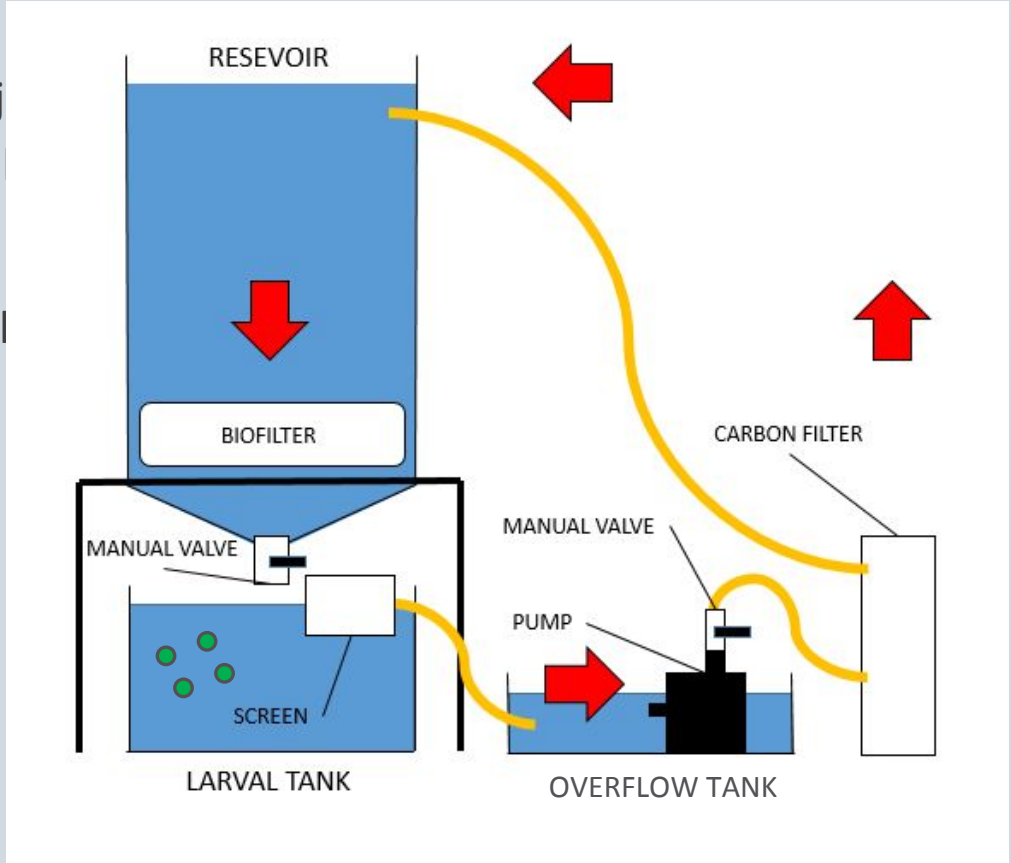
Methods:
Recirculating System Design 1

Setbacks:

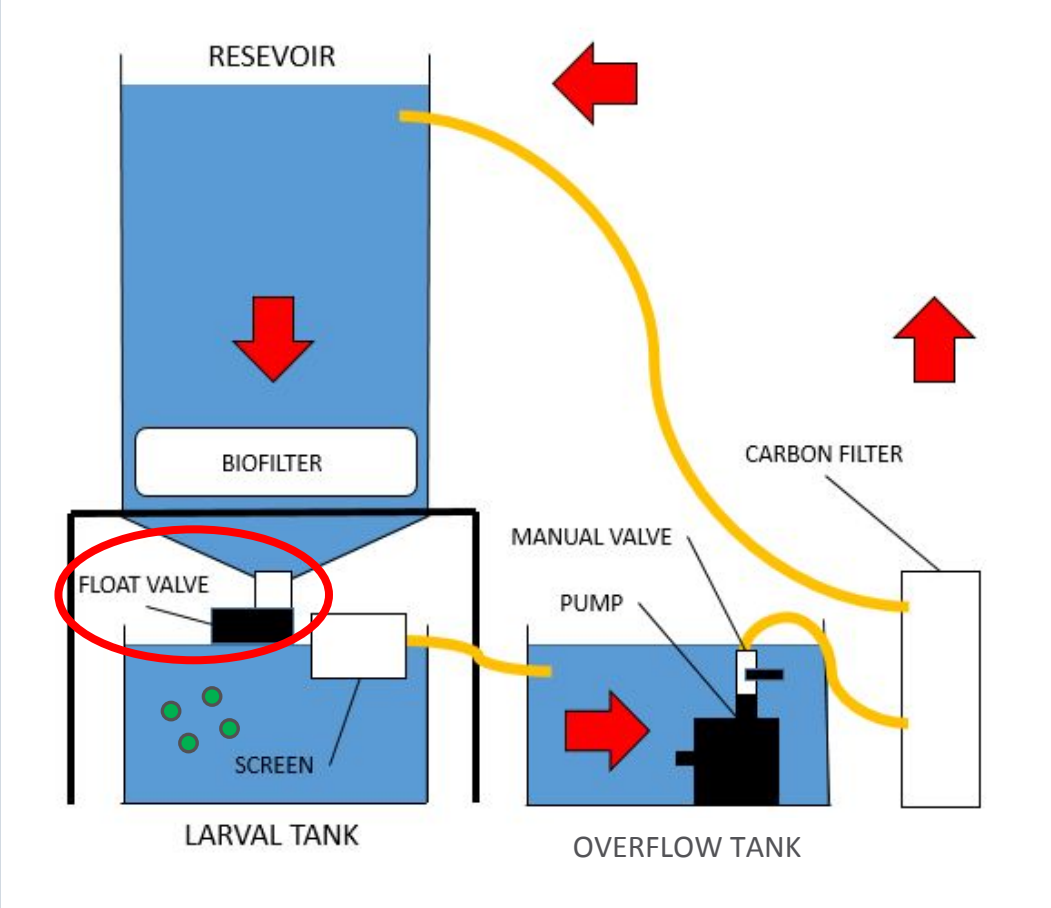
- Valves require precise adj
- Difficult to maintain equa

Solution:

- Replace manual valve wit



Methods:
Recirculating System Design 2



Methods:
Recirculating System Design 2

Benefits:

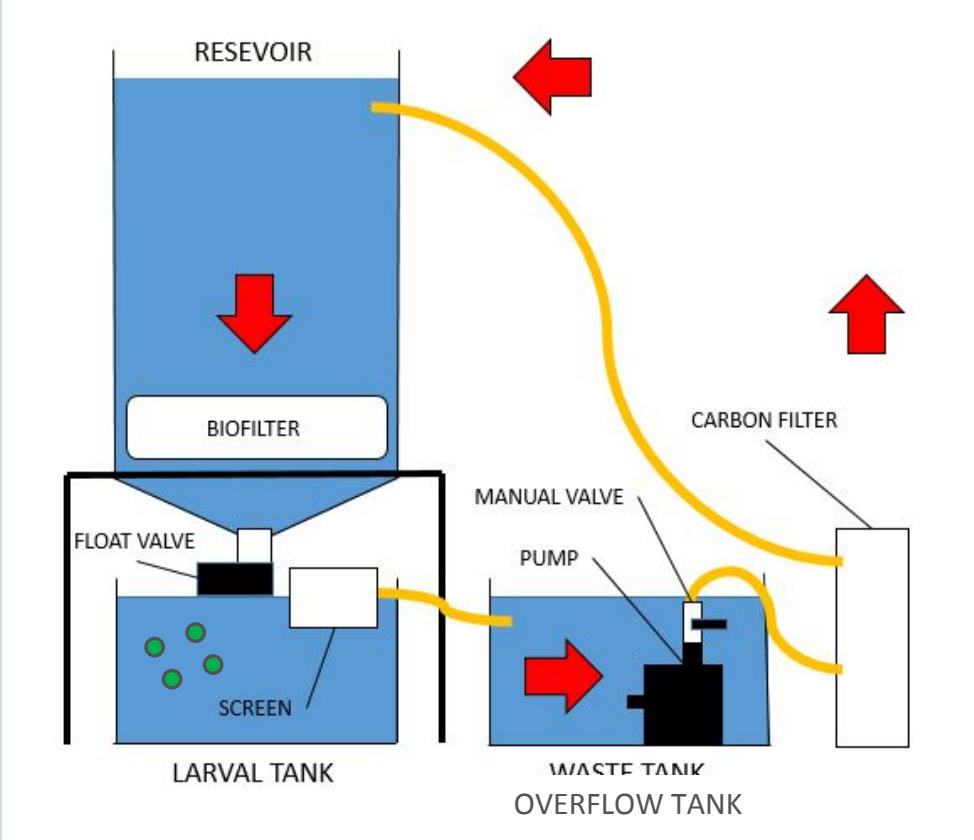
- Float valve automatically adjusts water flow

Setbacks:

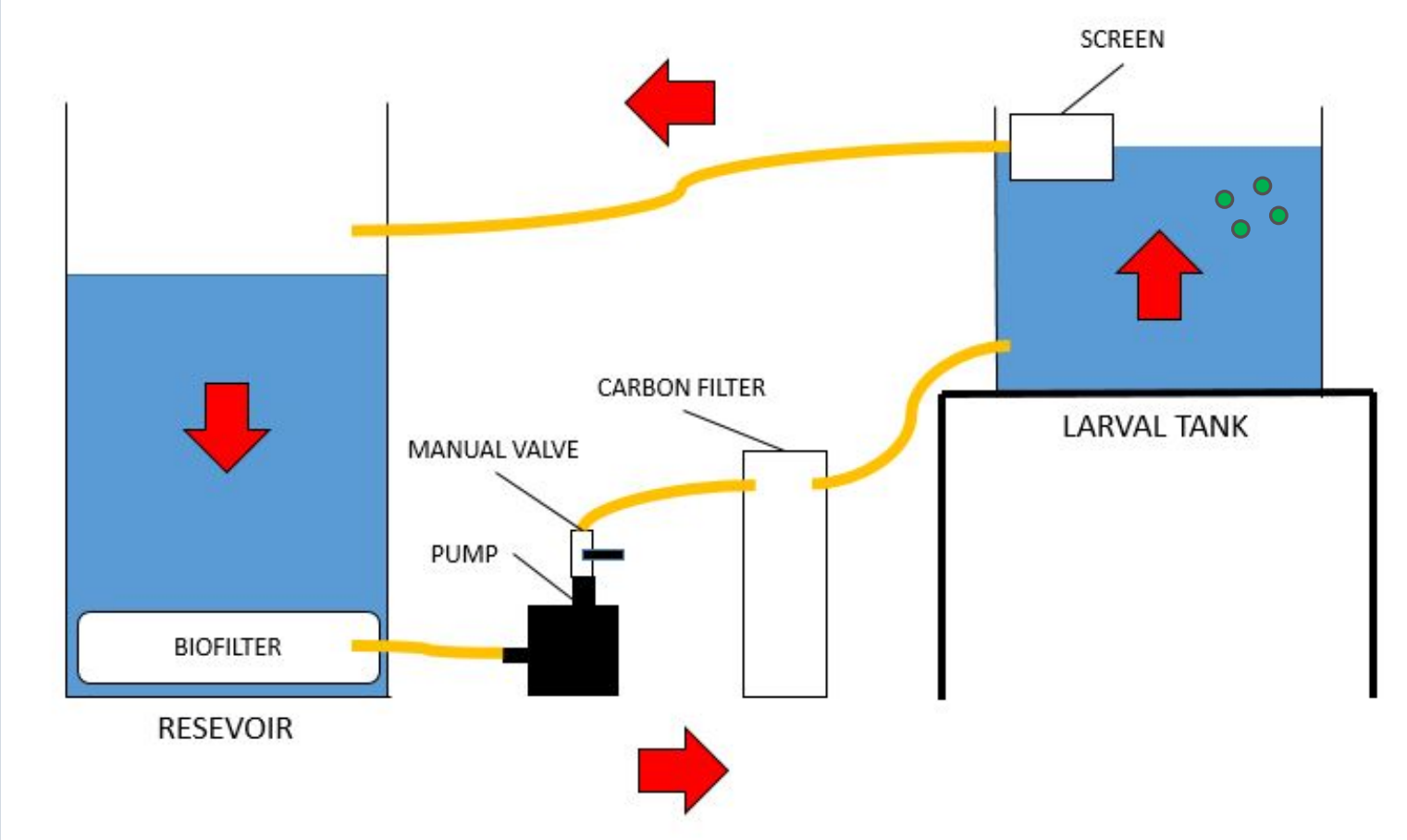
- Float valve diminishes overall water flow

Solution:

- Eliminate second valve
- Reduce number of tanks
- Suspend larval tank above reservoir



Methods:
Recirculating System Design 3



Methods:
Recirculating System Design 3

Benefits:

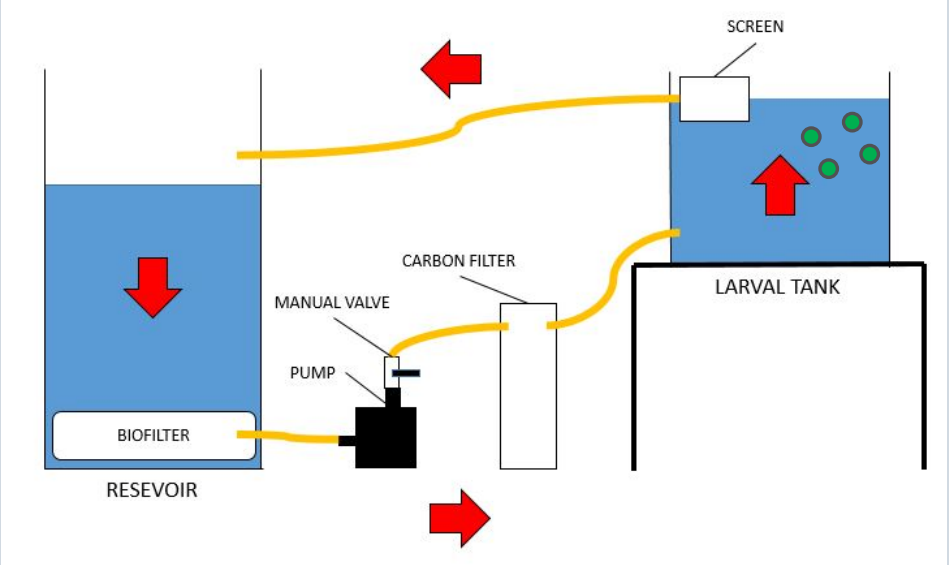
- Simplified design
- Single valve

Setbacks:

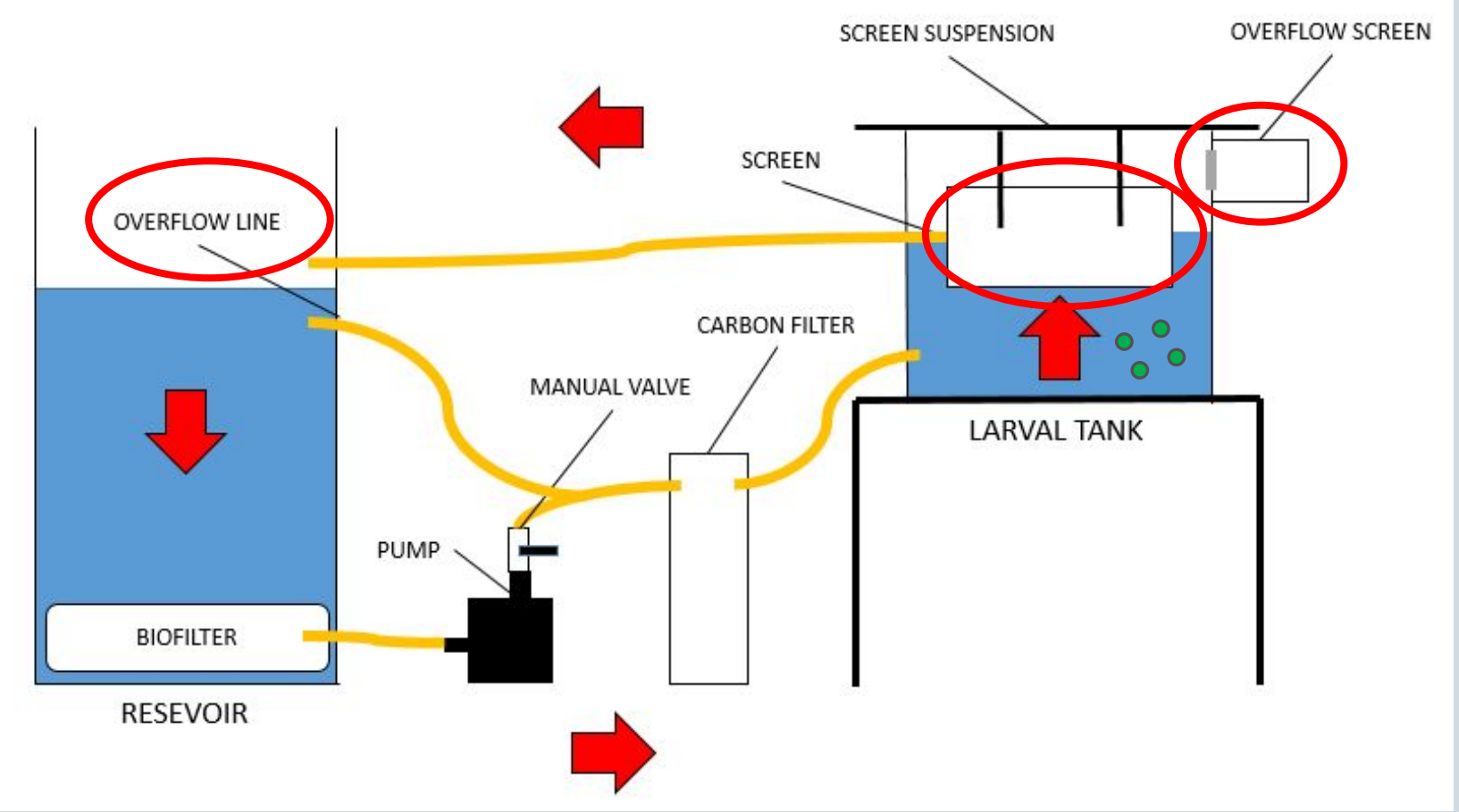
- Pump malfunctions
- Screen malfunctions
- Larvae escaping

Solution:

- Add overflow hose
- Add overflow screen
- Improve screen structure
- Seal loose connection



Methods:
Recirculating System Design 4



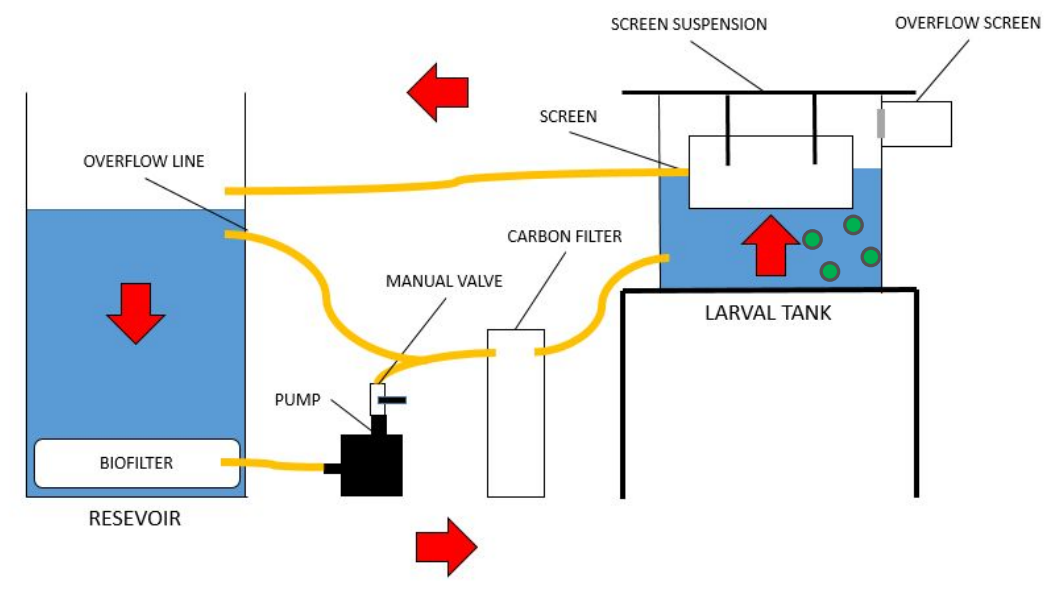
Methods:
Recirculating System Design 4

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)

	Item	Unit	Price/Unit	Used	Cost
Recirculating System					
Variable Expenses					
	Labor	Hour	$21.37	80	$1,709.60
	Larva	Quar	$39.69	80	$3,175.20
	Electr	Kilow	$0.11	80	$8.80
	Electr	Kilow	$0.11	80	$8.80
	Electr	Kilow	$0.11	80	$8.80
	Electr	Kilow	$0.11	80	$8.80
	Seaw	Gallo	$0.05	89	$4.45
	Pool S	40 Lb	$8.42	0.025	$0.21
Fixed Expenses					
	80 ga	Tank	$576.71	1	$576.71
	50 ga	Tank	$198.00	1	$198.00
	Tank S	Stanc	$1,110.00	1	$1,110.00
	Supre	Pump	$74.99	1	74.99
	Camp	Cartr	$17.99	1	17.99
	Penta	Hous	$45.00	1	45.00
	Rubb	2-pac	$5.88	1	5.88
	60 un	Squa	$48.60	0.037	1.7982
	DAP s	Tube	$3.64	1	$3.64

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

Design 1-2

Design 3-4

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.
- KAMERMANS, P., A. BLANCO, S. JOAQUIM, D. MATIAS, T. MAGNESEN, J.L. NICHOLAS, B. PETTON, R. ROBERT. 2016. Recirculation nursery system for bivalves. *Aquaculture International* 24: 827-842.
- MERINO, G., E. URIBE, G. SORIA, E. VON BRAND. 2009. A comparison of larval production of the northern scallop, *Argopecten purpuratus*, in closed and recirculating culture systems. *Aquacultural Engineering* 40: 95-103.