# Process Monitoring and Control in the Next Generation Hatchery

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# Overview

- Why focus on automation?
- Why is it challenging in marine hatcheries?
- Levels of automation
  - Examples of current technology
- The next generation hatchery

# Why focus on automation?

Some of the challenges faced by the Norwegian cod hatcheries:

- Better consistency of survival and growth
- Higher stability of culture conditions
- Lower costs

Process monitoring and control addresses all three issues through:

- Consistent treatment
- Optimization
- Less manual work

# Why is automation challenging in marine hatcheries?

- The production involves complicated biological processes:
  - Knowledge sometimes limits model development
- Monitoring and control require accurate measurements:
  - Need specialized instrumentation
  - Is it possible to estimate what we cannot measure?
- The processes consist of live organisms:
  - Special demands with regard to handling
  - Equipment and tubes must be kept clean
- Seawater is a very corrosive agent:
  - Electronic devices must be protected
  - Choice of materials is very important

# Examples of Current Technology

"Codtech" lab at Sealab in Trondheim

*CODTECH: a strategic university programme at NTNU in 2003-2007: a process-oriented approach to intensive production of marine juveniles with main emphasis on cod*

# Levels of development in automation

1. Manual control

- Manual control, visual observation

2. Instrumentation and mechanization

- Sensors, pumps, valves...

# Example: Cameras for Visual Observation

Online images from larval tanks can be accessed over the network

# Levels of development in automation

1. Manual control

- Manual control, visual observation

2. Instrumentation and mechanization

- Sensors, pumps, valves...

3. Open loop control

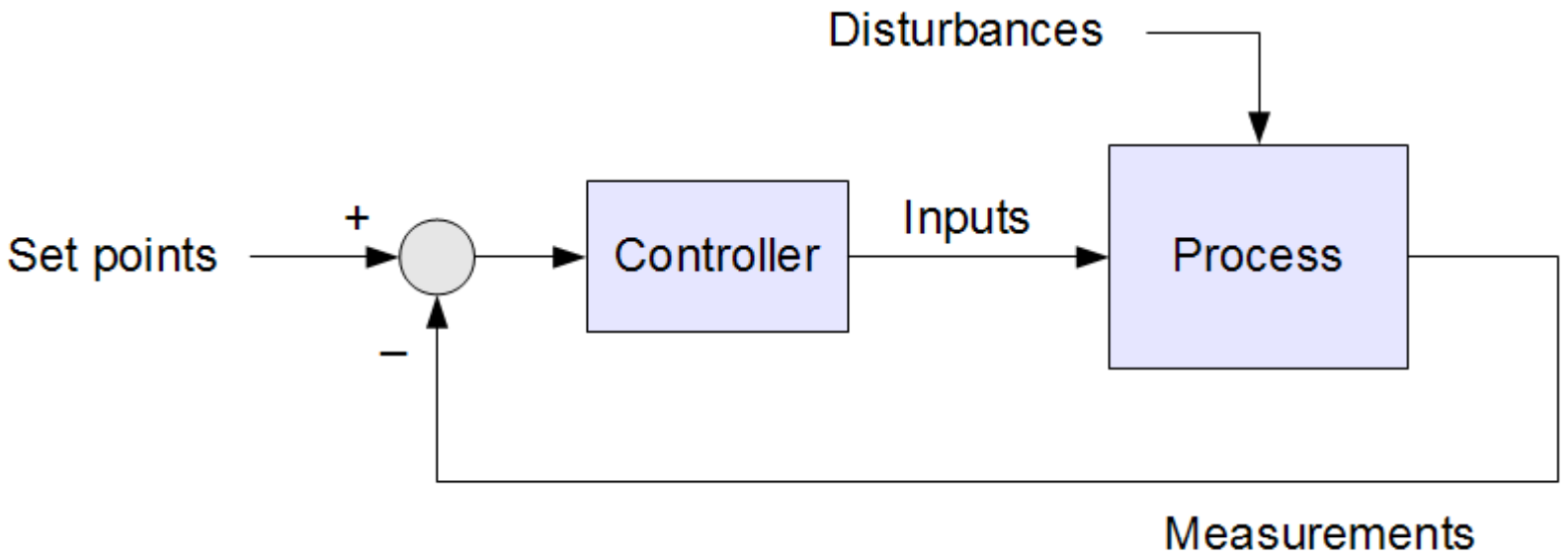
- Preprogrammed sequential controls (PLCs etc.)

# Examples: cleaning arm, water flow rate

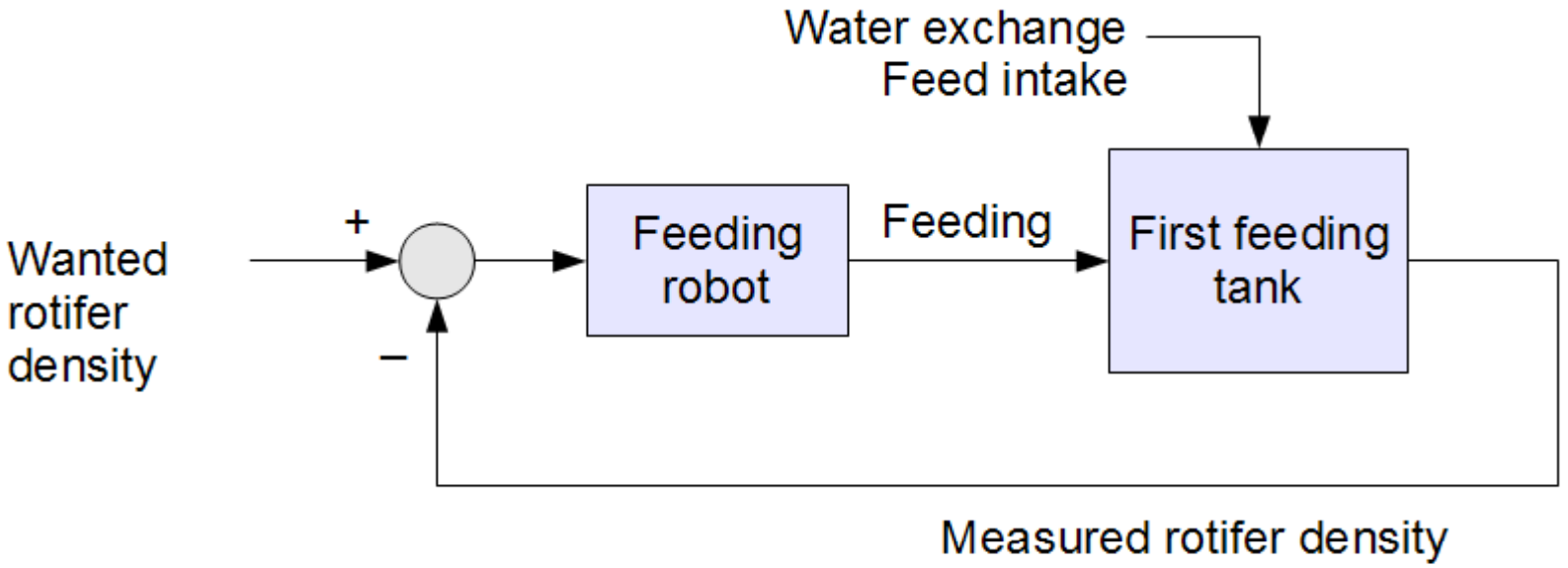
# Levels of development in automation

1. Manual control
   - Manual control, visual observation
2. Instrumentation and mechanization
   - Sensors, pumps, valves...
3. Open loop control
   - Preprogrammed sequential controls (PLCs etc.)
4. Closed loop control
   - Feedback from instrumentation used to direct control inputs

# Closed Loop Control



# Closed Loop Control



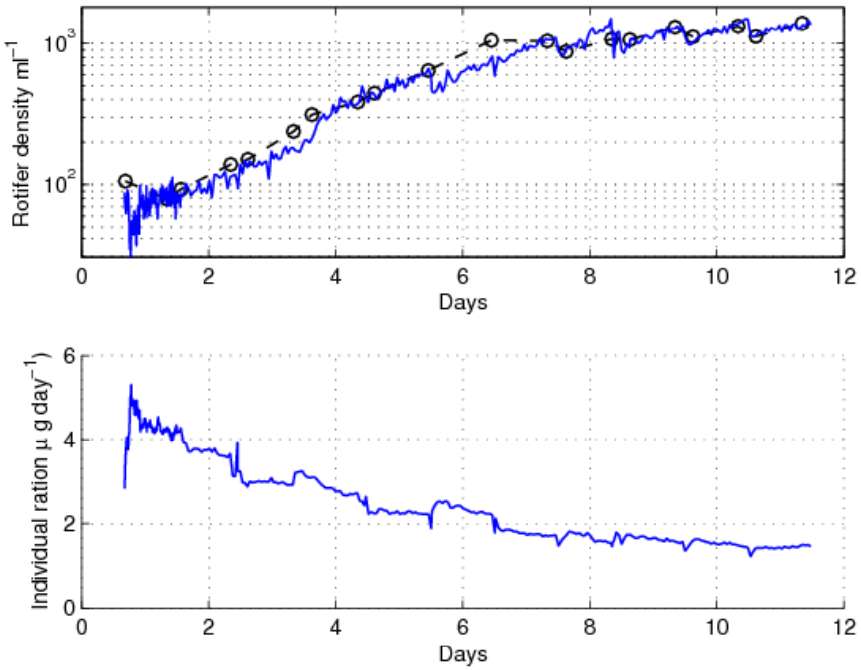
# Example: Appetite Controlled Feeding

Feeding robot from Storvik Aqua AS linked with rotifer density counter in order to control feed density in first feeding tanks


# Example: Rotifer Production

Automatic monitoring of rotifer density allows feedback control of rotifer density or growth rate.

*Automatically controlled rotifer culture with setpoint at 1000/ml:*



# Levels of development in automation

1. Manual control

- Manual control, (mostly) visual observation

2. Instrumentation and mechanization

- Sensors, pumps, valves...

3. Open loop control

- Preprogrammed sequential controls (PLCs etc.)

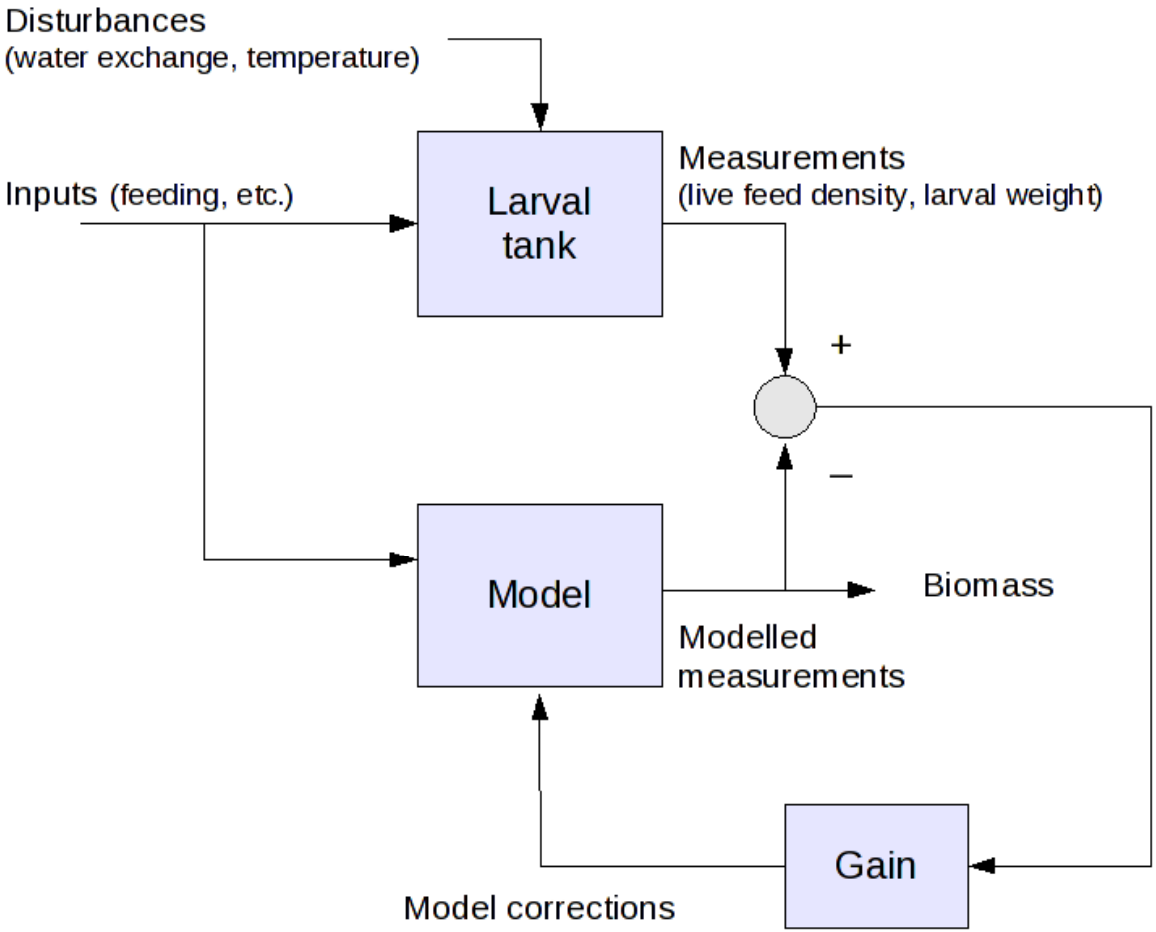
4. Closed loop control

- Feedback from instrumentation used to direct control inputs

5. Advanced process control

- Advanced control engineering techniques such as model based control and optimal control.

# Example: estimation of larval biomass




*Alver, M. O.; Alfredsen, J. A. & Øie, G.: Estimating larval density in cod (*Gadus morhua*) first feeding tanks using measurements of feed density and larval growth rates. Aquaculture, 2007, 268, 216-226.*

# The Next Generation Hatchery

# The Control Room

All information about all processes in the hatchery is available from the control room

- Environmental parameters.
- Density of live feed.
- Estimated number of larvae, estimated size and feed intake rate.
- Density of live feed cultures. Egg rate in rotifer cultures.
- Video images from tanks.

# The Control Room

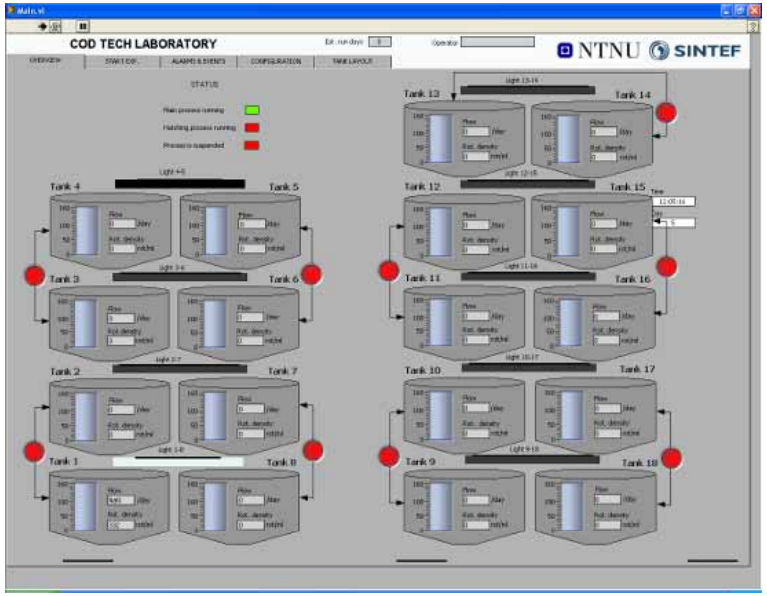
Production parameters can be adjusted from the control room:

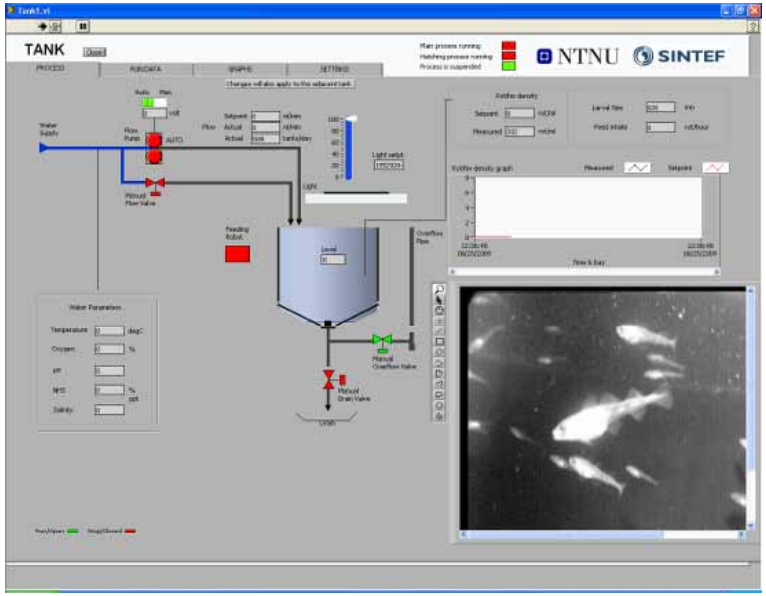
Temperatures, oxygen levels, water exchange rates, light level

Set points for feeding

Setpoints for live feed production

The operator’s role will be to oversee and direct production



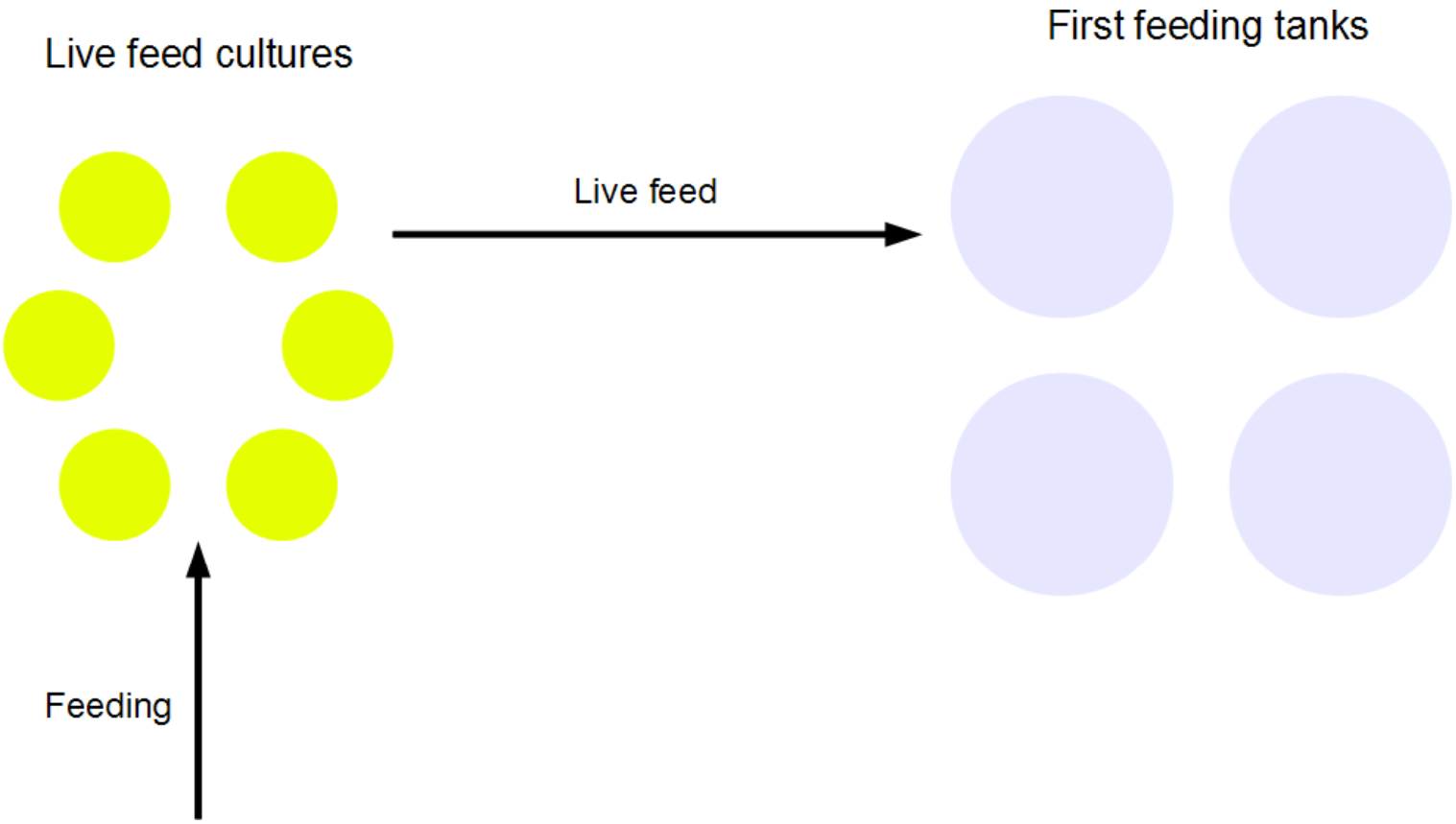
# The Control Room

The control room's panels can be accessed from anywhere over the network

(photo from the SINTEF Surveillance, Simulation and Operation facility)

# Management and Planning

Models and monitoring used to optimize live feed production:



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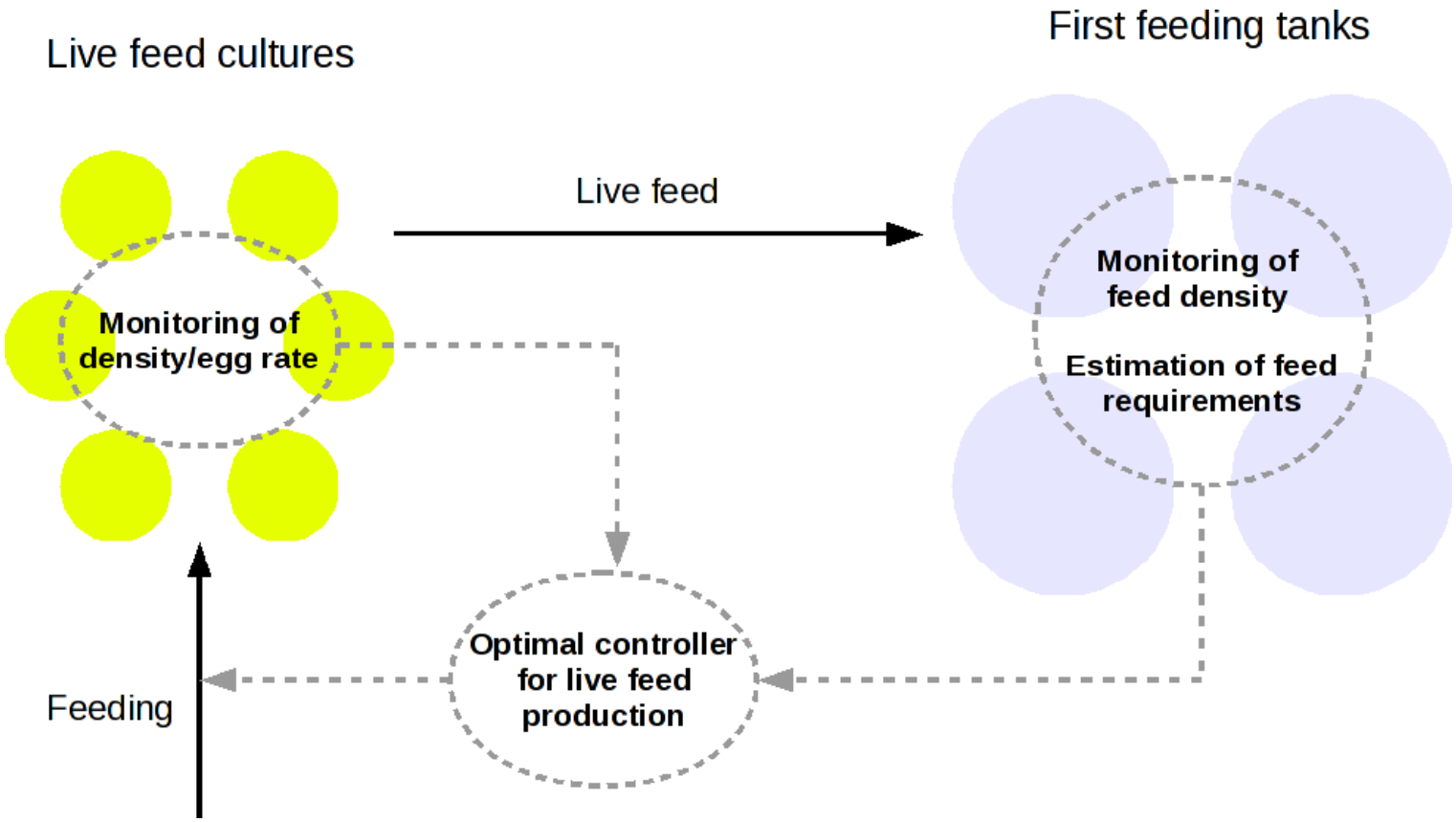

# Conclusion

- Monitoring and control systems make the hatchery an integrated and optimized production line
- The operator's role will mainly be supervision and management, with less manual operations than in current hatcheries
  - This will enable scaling to much larger hatcheries
- Requires attention to the challenges of the hatchery environment