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

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

Wanted rotifer density

Water exchange
Feed intake

+ Feeding
- Feeding

First feeding tank

Measured rotifer density
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

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:

Live feed cultures → Live feed → First feeding tanks

Feeding
Management and Planning

Models and monitoring used to optimize live feed production:

- Live feed cultures
- Monitoring of density/egg rate
- Feeding
- Optimal controller for live feed production
- Monitoring of feed density
- Estimation of feed requirements
- First feeding tanks

Live feed
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